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Buying Motors to Use— Not to Repair

Is a real job under some industrial installation and operating conditions —How do you do it?

HERE is a photograph that I have received from Mr. Mark Hoeper of the American Electric Motors Inc., Milwaukee, Wis., which shows surroundings where the Imps of Satan like to dance about when successful in creating for the repair man bearing and winding troubles in open types of motors. Such troubles are here avoided by the use of a self-ventilated, totally-enclosed, ball-bearing motor for which a non-maintenance service record is claimed. In this connection Mr. Hoeper says:

This dirty picture shows the conditions under which this 5-hp., 1,200 r.p.m., ball-bearing motor must operate in driving a core sand mixer.

More or less sand is spilled out of the mixer cylinder and gradually considerable of it accumulates on the motor. The air inlet manifold for the ventilation does not appear on the photograph as it is mounted on the back side of the motor for convenience in piping clean air to the motor through the outside of the building. The back gears, you will notice, are totally enclosed, so that they run in a bath of oil or grease, and so that no dirt can get inside of the gear case. The back gear frame can be mounted on top of the motor or on either side. The back gears can be mounted at either end of the motor and the air inlet manifold can be mounted in any of these three positions not occupied by the back gear shaft assembly.

Dust, grit, fumes, oil, and water, drive more motors into the repair shop than long years of hard service under favorable operating conditions. Every man who has to fight against these trouble-makers listens with ears and eyes when new or better remedies are proposed for they save his time for other duties and help to reduce the installation and maintenance costs that are charged to his department.

I am looking all of the time for the men who have worked out installation, inspection or other methods to enable motors to live their lifetime with the lowest repair and maintenance cost.

If any of you who read this have a pet scheme or an installation that has done the trick and kept your motors on the job and out of the repair shop, I shall certainly appreciate the details so that we can talk the matter over together on this page and after a while get somewhere on this question of buying motors to use and not to repair.

Practical Pete

A Glimpse into the Works of the

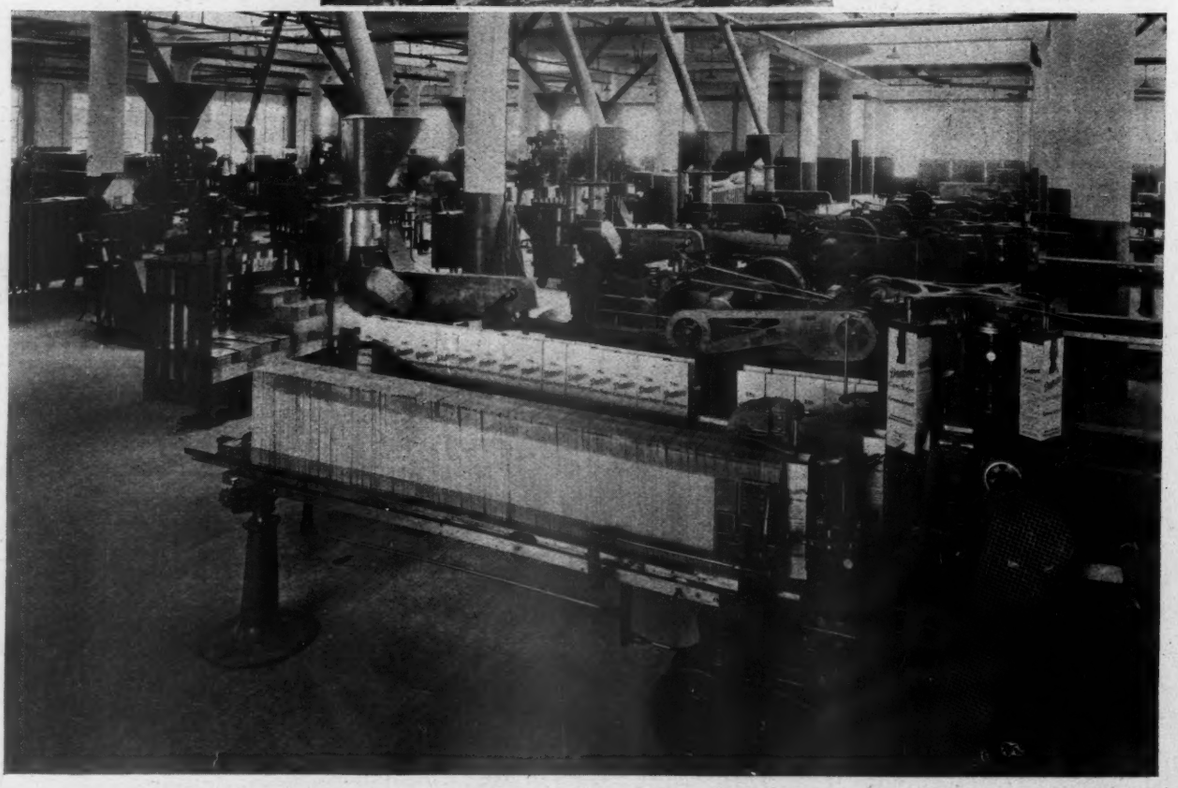
American Sugar Refining Company

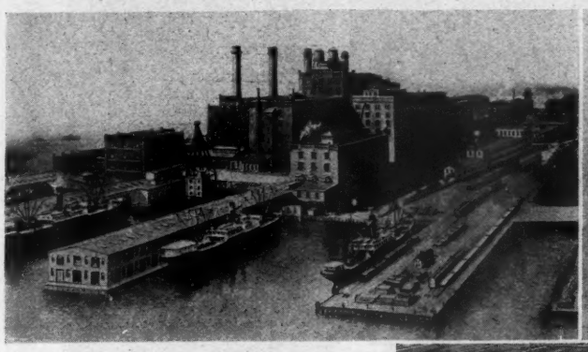
Where raw sugar is refined by twenty to thirty processes into forty-four grades and put into ninety-six packagings for use. The eleventh of a series devoted to the growth and extent of our basic American industries.

Two views of the Baltimore, Md., plant and an automatic packaging machine filling 5-lb. cartons with "Domino" granulated sugar. The folded cartons are fed into a mechanism which opens them, closes and seals the bottom. The cartons then pass on to the filling machine where they are filled weighed, closed, and sealed automatically. In process the sugar is not touched by hand.

A TRAIN of box cars reaching from Boston to Denver would be required to haul all the 5,000,000 long tons of refined sugar consumed annually in the United States, which is about a fourth of the sugar produced in the world. The section of this train between New York and Cleveland would hold about the amount produced by the

American Sugar Refining Company, which is around 1,500,000 long tons. Sugar has been known since the beginning of the Christian Era. At first it was costly and was used only in medicine. During the past hundred years it has come into general use because mechanical improvements in the refinery have made the production of sugar possible at low cost and within





Three other plants of the American Sugar Refining Company.

The plant above at the left is the Philadelphia refinery. The one above at the right is the Brooklyn refinery, which is about 60 years old and until 1890 was the largest refinery in the country. It was originally one of the Havemeyer factories which was later incorporated into the American Sugar Refining Co. The airplane view is of the Chalmette refinery near New Orleans. All have adequate waterfront.

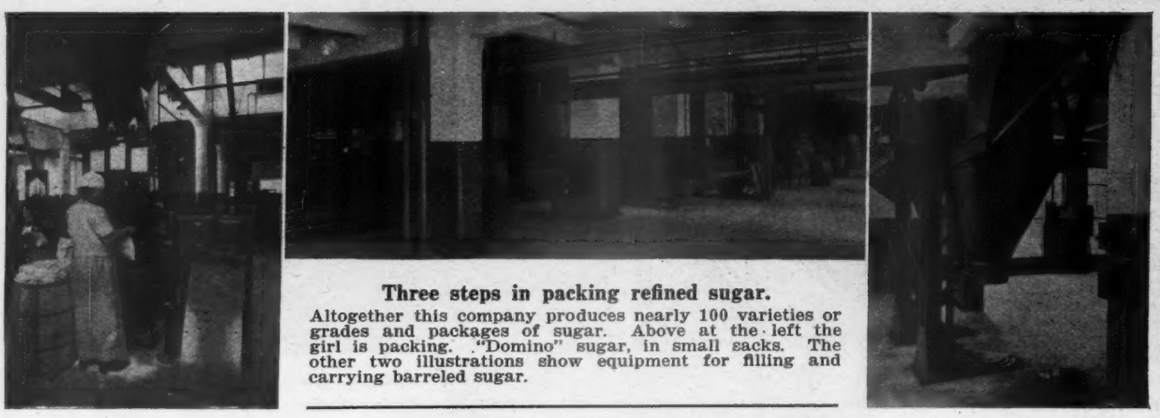
the purse of all. However, a hundred years ago granulated sugar was still unknown.

The art of refining consists in converting raw sugar into refined grades with a minimum loss of sucrose content. Today, a loss of 6 to 7 lb. in a hundred, in refining raw sugar of average test, is all that is expected. In 1816 a refiner could obtain from 100 lb. of raw sugar only about 50 lb. of refined sugar, 25 lb. of molasses and 25 lb. of so-called bastard sugar. The present method of refining involves between twenty and thirty steps, or processes, depending upon the grade or form of the refined product. The American Sugar Refining Company manufactures forty-four kinds or grades of refined sugar put up in ninety-six ways.

In the course of a century, the invention of the centrifugal machine, the vacuum pan, the boneblack filter and the polariscope has revolutionized the refining methods. The fundamentals, to be sure, remain the same as in Colonial days. It was then necessary to melt, clarify, filter, and crystallize by boiling the raw product. Today the same steps must be followed, but the methods employed in the various processes have all been changed radically. Formerly, raw sugar was melted in a large open kettle or copper boiler; the liquor filtered by straining through blankets, and then clarified by the use of bullock's blood, albumen and clay. The purified sugar was then run into molds and placed in ovens which were heated to the proper temperature. This formed the old loaf sugar. The use of the boneblack filter has done away with the old clarifying agents, oxblood, clay and albumen. Boneblack quickly and thoroughly cleans raw sugar. Employing it together with bag filters and filter

Three steps in the refining of sugar.

The dissolved raw sugar syrup is poured into the filters above where the syrup passes through boneblack, charcoal made from animal bone, to remove the impurities. It then goes into the vacuum pans above where it is boiled under a partial vacuum at a temperature low enough to prevent the sugar from carmelizing. The above illustration shows a battery of screens which receive the finished sugar from the centrifugal machines. It is discharged on a belt conveyor which carries it to chutes emptying into storage.



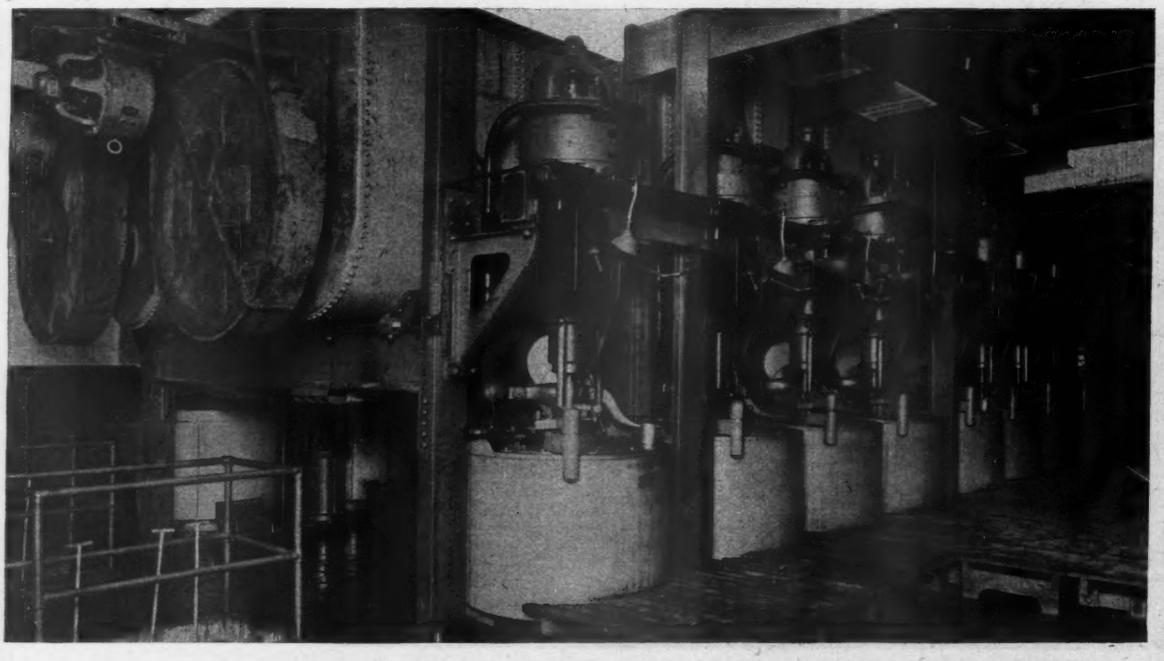
Three steps in packing refined sugar.
Altogether this company produces nearly 100 varieties or grades and packages of sugar. Above at the left the girl is packing. "Domino" sugar, in small sacks. The other two illustrations show equipment for filling and carrying barreled sugar.

presses which take the place of the old-fashioned blankets, the modern refiner is able to produce sugar free from any impurities.

The polariscope now makes it possible to determine exactly the sucrose content, that is, the amount of pure sugar in any raw sugar. By its use the buyer of raw sugar is able to ascertain to a fine degree the value.

Granulated sugar has been made possible by the invention of the centrifugal machine and the modern granulator. Sugar liquor, after boiling, is put into the centrifugal machine, a large perforated drum which revolves about 1,100 r.p.m., throws the molasses off and leaves the white sugar granules in the basket. The granulator dries the sugar and divides it by screens into three grades. After the sugar has been manufactured, it is conveyed and packed entirely by clean machinery which weighs it, places it in cartons, cotton bags or barrels and seals it.

What might be called the start of the American Sugar Refining Company was a refinery erected by the Havemeyers in the early part of the nineteenth century, in a little building, 25 ft. by 40 ft. in size, with only four or five employes. The sugar business which started in this little refinery was handed down from generation to generation, expanding until in 1890 it was the largest refinery in the world. About that time this refinery and several others were combined to form the American Sugar Refining Company. Today the largest refinery of this company can refine in two days approximately the total amount of sugar refined in New York City in 1816. The company has refineries in Baltimore, Brooklyn, Boston, Philadelphia and Chalmette, near New Orleans. It also owns two sources of raw sugar supply in Cuba. These require 12,000 men for 150 days to cut and haul the cane, and 1,300 more for the *(Continued on page 564)*



A battery of centrifugal machines with direct-connected motor drives. After the sugar has crystallized in the syrup from the vacuum pans the liquor is poured into these centrifugal machines. These consist of perforated drums which revolve at high speed and throw the syrup out while retaining the sugar. The sugar then goes on through the screens and finally to the packing rooms.

CIRCUIT BREAKERS when correctly installed will often save more than they cost. They will protect service lines, motors, driven machines, and prevent waste of the product being made. In addition they will reduce service interruptions and the losses accompanying them, which is often a large item in production costs. In this article information is given that will help to determine the type of circuit breaker that is best suited to service conditions and protection for direct-current motors. A later article will cover protection for alternating-current motors and power and lighting feeders.

Some Practical Pointers on

Circuit Breakers for D. C. Motors

Their Operation Under Differing Load Conditions and Hints on Care

The operator is shown here putting in the breakers that protect a crane.

By JAMES H. WYATT

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AN OVERLOAD circuit breaker should protect the motor and motor-driven machine from being unduly loaded through any cause whatever. Overloads may be occasioned by too rapid starting of the motor, by working the motor-driven machine beyond its capacity, by faulty adjustments in the driven machine, by the presence of foreign bodies in its working parts, and by a variety of similar causes.

In the selection of overload circuit breakers for direct-current motor protection, due attention should be paid to the amount of current required at starting. With hand-starting rheostats of the usual types the starting currents of direct-current motors of the sizes in ordinary commercial use run in the neighborhood of 150 per cent of full-load current, and circuit breakers should be chosen which have a sufficiently high adjustment to meet this requirement satisfactorily. Table I indicates the sizes of circuit breakers best adapted for the protection of various sizes of motors from ½ hp. to 100 hp. at 125, 250 or 500 volts, direct current. The figures given in the left-hand column indicate the horse-power of the motors at full load; the remaining columns show the ampere ratings of the circuit breakers required for each of the voltages given.

Close Protection With Heavy Starting Currents

Where the operating point of the overload circuit breaker is set only slightly above the point corresponding to the load current, the circuit breaker, when connected in the motor circuit, will instantly open in the event of any serious irregularity of operation such, for instance, as the catching of a tool or the jamming of material. The degree of protection which may be secured against such contingencies is limited ordinarily by the amount of current required for starting the motor, because, unless some special construction or method of operation is employed, the setting of the circuit breaker must be slightly in excess of that corresponding with the starting current. Under ordinary conditions the circuit breaker, when set in this manner, will still be sufficiently sensitive to afford the desired measure of protection. But where the material being worked is of great value and of a readily destructible nature, or where the machinery involved is fragile, complicated and easily thrown out of adjustment, sensitiveness to even slight increases in the load above the normal is a most desirable characteristic of the circuit breaker.

This exacting condition may be met by the use of a specially constructed circuit breaker provided with two independently adjustable overload features, one operative throughout the starting period, and the other only when the starting resistance is cut out. By this means the sensitiveness of the circuit breaker during running conditions, being entirely independent of the current required for starting, may be increased to any desired point.

Obtaining Protection Against Sustained Overloads

In contrast with the foregoing there are other and much more usual conditions in which it is not desirable to have the circuit breaker operate in the event of briefly sustained overloads of inconsiderable magnitude, but to limit its action to that occasioned by sustained overloads or those of excessive magnitude. Such conditions are met, for instance, in the operation of motor-driven punches, rolls or shears, in which the load comes upon the motor intermittently, thereby causing sudden and considerable, although briefly sustained, increases in the current flow. For such service the overload feature should have an inverse-time lag; that is, it should be sensitive to small overloads only when continued unduly, but should respond more quickly to the heavier overloads, the time lag becoming less as the overload increases, and altogether disappearing in the case of excessive overload. The ordinary

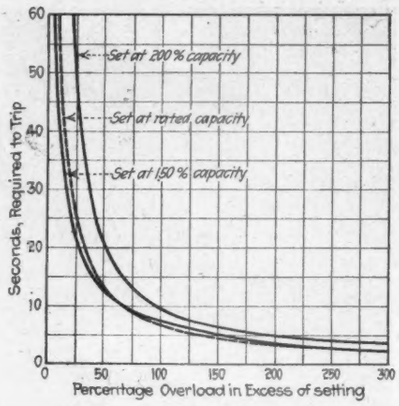


Fig. 2—A good circuit breaker acts similarly with any setting.

These curves are for a 150-amp. breaker with a properly designed inverse-time feature. The dotted line shows the time required to trip the breaker at different loads when set to trip at normal rating. When set at a higher value its action as seen from the curves is nearly the same. For instance when set for rated current, if a load 50 per cent above the setting comes on, the breaker will trip in about 13 seconds. Again if set for 150 per cent of normal current, it will take approximately 12½ seconds to trip at a current 50 per cent above this.

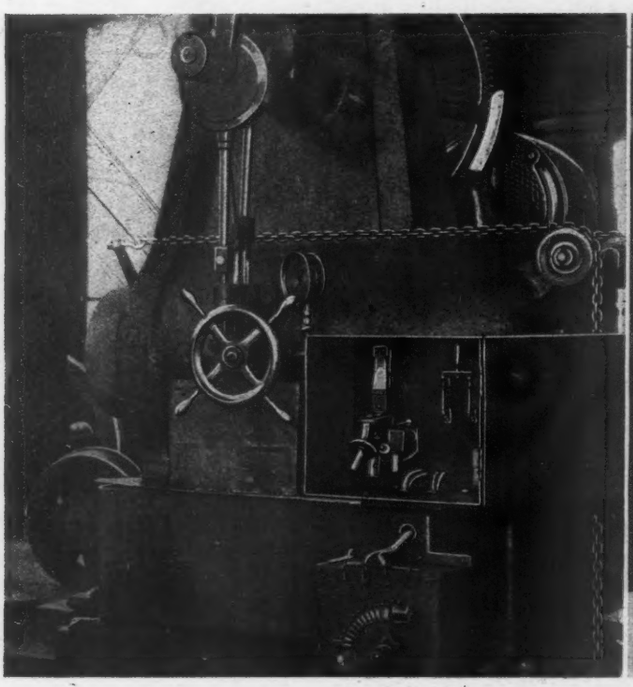
form of overload circuit breaker does not discriminate between momentary and sustained overloads, but in any case operates the instant the current flowing exceeds that for which the instrument is adjusted. If, to meet these conditions, the tripping point of this form of circuit breaker be set so high as to be unaffected by momentarily excessive currents it will be likewise insensitive to sustained overloads of the same magnitude, and to this extent will be ineffective as a means of protection. If, on the other hand, the tripping point be set so as to give protection against current values which, if sustained, would cause damage, then momentary fluctuations of the current to the same magnitude will occasion unnecessary opening of the circuit breaker. These small momentary increases of current would not, of course, harm the motor.

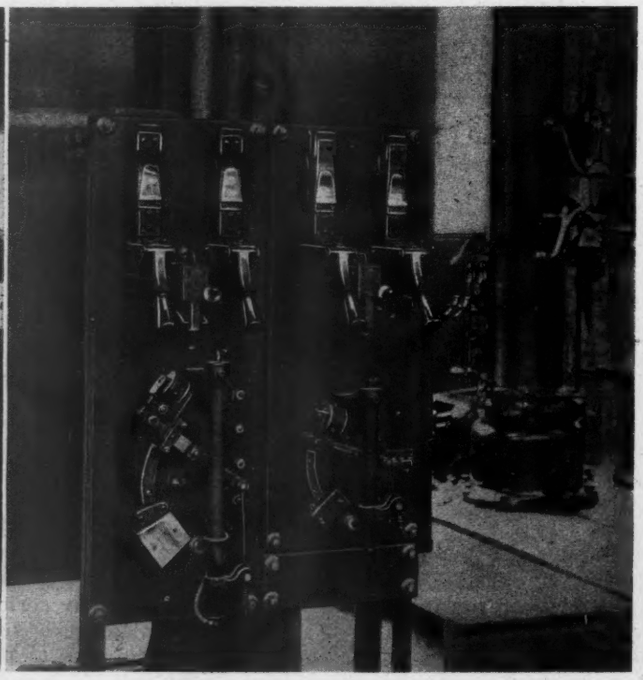
Characteristic curves of the operation of a circuit breaker with the time-lag feature are shown in Fig. 2. The breaker is rated for 150 amp. It will be seen that if a load of 300 amp. comes on the motor (100 per cent overload) the breaker will trip in about seven seconds. If a load of 600 amp. (300 per cent overload) comes on, the breaker will trip in two seconds.

There is another desirable feature of a circuit breaker which these curves bring out. This feature is constancy of action under various settings. This means that the 150-amp. breaker may, perhaps, be set to trip at 200 amp. on short circuit. This is 50 amp. above its nameplate

Fig. 1—Circuit breakers on motor panels.

At the left is an application of breakers with motor starters. These breakers replace both hand switches and fuses. In case of an overload on the circuit the first breaker opens as the second is being closed. These panels are in the plant of the Kempsmith Machine Tool Company, Milwaukee, Wis. At the right is a board showing breakers which protect and control power feeders and individual motors in a plant of the Diehl Manufacturing Company.





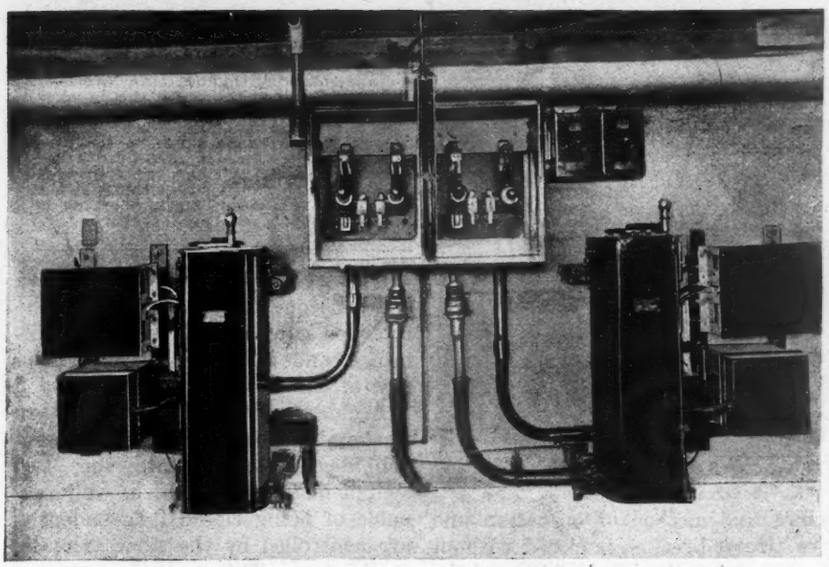


Fig. 3—Circuit breakers mounted at the drum controllers of two 75-hp. motors driving molasses pumps.

tripping current. Now if it is a good breaker it will act at this higher setting the same as it did at its normal setting. In other words at 100 per cent overload above 200 amp. it will trip in about 7 seconds, just as it tripped in 7 seconds before with an overload 100 per cent above the former setting of 150 amp. The curves in Fig. 1 bring out the fact that this breaker will act in almost exactly the same way for a setting 50 per cent above normal. Even with a setting of 200 per cent of normal the action is not greatly different.

Another important point in the time-lag device is the means employed to get a delayed action. The operation should be such that the time lag will depend on the current magnitude not only at the start of the action but during the whole operation. In a poor design after a heavy current starts the mechanism into operation, it may continue to operate even though the current will subsequently drop to a value lower than the tripping value.

Means for Opening Breaker on Failure of Voltage

Where the source of current supply is liable to occasional interruption a *no-voltage* feature is an essential adjunct to the circuit breaker for motor protection. The no-voltage device will open the breaker when the voltage falls to a low value. The direct-current motor is so constructed that it should be brought into circuit gradually, as by means of a suitable starting resistance. If, thereafter, the power supply is interrupted long enough to permit the motor to slow down materially or to stop altogether and is then restored with the motor starter in the running position, the motor receives current much in excess of its capacity, a condition which is likely to result in injury, not only to the motor, but also to the machine driven by it. The no-voltage circuit breaker prevents this by automatically disconnecting the motor from the line when, after the cessation of the power supply, the speed of the motor falls much below normal.

For manually-controlled, variable-speed motors the no-voltage circuit breaker is especially valuable, as it is not usual to embody the protective features afforded by this type of apparatus in the controllers employed for this class of motor. The no-voltage circuit breaker protects, more effectively than any other piece of apparatus, against the conditions incident upon interruption of service, because being especially designed for opening circuits, the final breaking points are of solid carbon. The main contacts are, therefore, not liable to burning and the instrument is free from the sticking to which other classes of switches are subject.

The circuit-breakers made by the Cutter Company equipped with the no-voltage feature are provided with a contact member for automatically disconnecting the no-voltage coil in advance of opening of the main switch member of the circuit breaker, thus protecting the coil from inductive discharge due to opening of the circuit breaker when carrying heavy current. Where no-voltage circuit breakers are employed it is good practice invariably to open the circuit by means of the circuit breaker or, where the circuit is likely to be opened by a hand-switch, to have one terminal of the no-voltage coil connected between

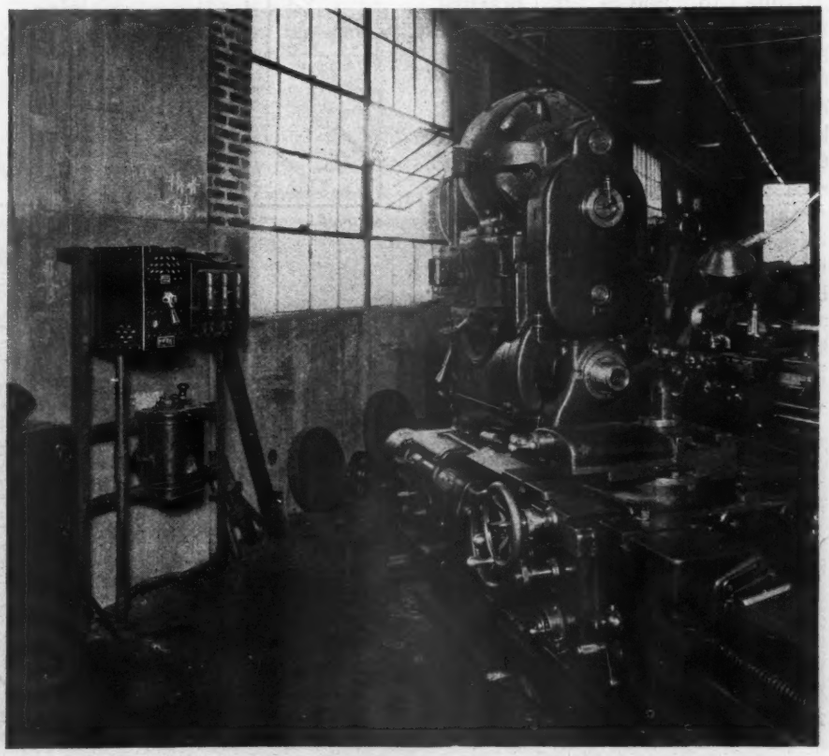


Fig. 4—Circuit breaker and automatic starter for a large lathe.
The circuit breaker has two poles that give full protection against overload, which is not afforded by the one overload coil of the starter when used on a grounded-neutral circuit.

the hand switch and the source of current. The coil will thus be relieved of the discharge incident upon the opening of the switch, which discharge is likely to be of considerable volume if the circuit contains highly inductive apparatus, as for instance, series or compound-wound motors or magnetic brakes.

It is desirable to have the no-voltage device arranged so that it will be automatically reset when the circuit breaker is closed, thus avoiding the necessity of bringing the no-voltage armature into engagement with the magnet by hand while the other hand is used to close the circuit breaker.

Is a Single-Pole or a Double-Pole Breaker Preferable?

The question often arises in choosing a circuit breaker for direct-current motor protection: "Shall a single-pole or a double-pole instrument be used?" The motor operated from a two-wire system is quite frequently protected by means of a single-pole circuit breaker which, if one of the mains of the system is grounded, should be connected between the motor and the ungrounded main.

A properly chosen single-pole circuit breaker arranged in this manner will afford adequate protection to the motor, provided the operation of the instrument is in no way interfered with; but this condition is one which, owing to the human element, it is almost impossible to realize in practice. Usually, in fact it is required by the rules of the Underwriters that where a single-pole circuit breaker is employed, a hand switch be used in series therewith. When the circuit breaker opens, the hand switch should be opened before the circuit breaker is closed. Then, when the circuit is completed by the closing of the hand switch, the circuit breaker is free to respond should abnormal load conditions exist on the line. When, through haste or ignorance, the operator fails to observe this method of operation and the circuit breaker is closed without first opening the hand switch, if the overload condition still exists, damage to the apparatus or to the operator is almost certain to result. This is because the circuit breaker handle will be in the grasp of the operator and consequently its opening will be retarded, causing the arc to be maintained and allowing the continued flow of the excessive current.

Accidents from this source are rendered impossible by the use of a double-pole instrument, the two switch members of which, while capable of being closed independently, are controlled by the same tripping mechanism. This type of apparatus is particularly adapted to the protection of motors whose control is likely to be in the hands of those whose knowledge of electricity is not

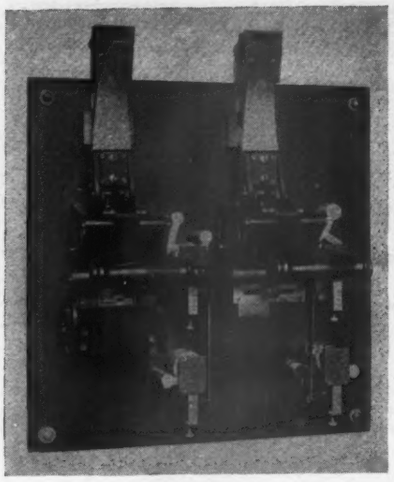


Fig. 6—Overload on any one of five motors trips this breaker.

This circuit breaker protects five crane-operating motors. An overload on any motor will cause the breaker to open. It has five overload devices, each having its independent adjustment with a range suited to the particular motor in the circuit of which it is connected. A shunt trip connected to a push button enables the operator to open the circuit at will. This is often a very desirable feature.

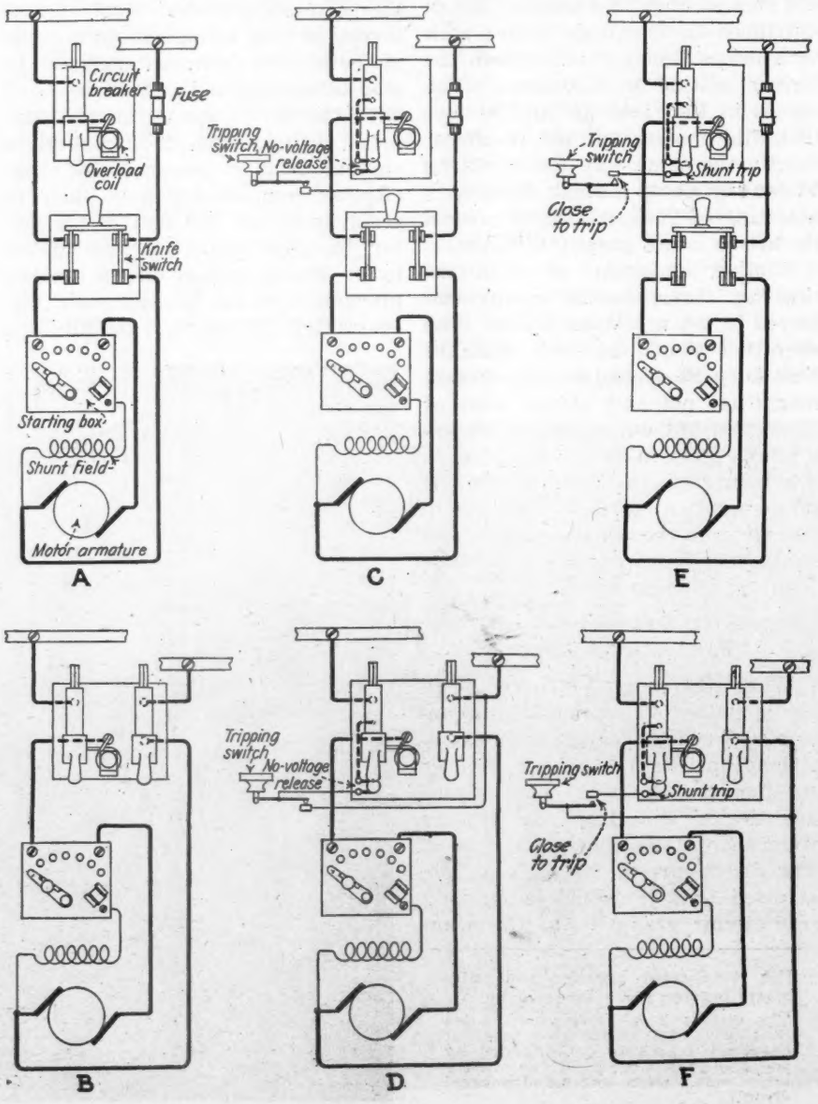


Fig. 5—Six ways of protecting d. c. motors with circuit breakers.

At *A*, *C* and *E* only one breaker is used for each motor, while at *B*, *D* and F two breakers are used. Where only one breaker is used a fuse and disconnecting switch must be provided in addition. Two methods of stopping the motor from a distance are shown at *C*, *D*, *E*, and *F*. A no-voltage release and tripping switch are shown in *C* and *D*. At *E* and *F* are a shunt trip and a tripping switch. When these methods of tripping are employed the control wire leading from the tripping switch directly to the line should attach to the grounded line wire. In the four cases shown the right-hand line wire should be the grounded one.

Table I.—Capacity of Circuit Breaker Best Adapted for Direct-Current Motor of Given Size

Hp. of Motor at Rated Load	Ampere Rating of Circuit Breaker		
	For 125 Volts	For 250 Volts	For 500 Volts
½	4	....	....
1	8	4	....
2	20	8	4
3	30	12	8
5	45	20	10
7½	60	30	20
10	80	45	20
15	150	60	30
20	200	80	45
25	200	100	60
30	300	150	60
40	300	150	80
50	400	200	100
75	600	300	150
100	800	400	200

such as to insure proper handling of the apparatus. With each motor protected by such a circuit breaker the usual hand switch is rendered superfluous and the possibility of damage from overload is completely eliminated.

This condition is also secured by the use of the type of circuit breaker which cannot be closed or held closed during the continuance of overload on the circuit which it protects. Should an overload arise during the act of closing, the switch arm will instantly be released from the closing lever and the circuit will be broken regardless of any pressure which may be exerted upon the handle.

In three-wire installations the neutral main is usually grounded. For the protection of the motor operated from such a system a double-pole, double-coil circuit breaker is, therefore, necessary in order to insure immediate response in the event of accidental grounding of either the positive or the negative main. In the event of such a ground between the circuit breaker and the source of current supply, the overload coil, if on the side of the circuit thus grounded, will be short circuited and thus rendered ineffective. Where, however, the instrument is provided with two overload coils, one of the two will always be effective in opening the circuit in the event of the condition described.

How Remote Control of Circuit Breakers is Obtained

Circuit breakers may be arranged for either closing or opening from a distant point. The closing may be done magnetically, by a motor or pneumatically. Breakers are made embodying all these means of control. Sometimes it is desired to have a circuit breaker so arranged that it may be opened by an operator at a distant location. This may be done in two ways: (1) By installing a shunt-trip device and its circuit, and (2) by running the circuit from the no-voltage coil to the distant place.

By either of these methods the breakers may be opened at once from any number of points. The shunt-trip feature consists of a tripping magnet having a high-resistance coil normally out of circuit, but adapted to be brought into circuit either automatically upon the occurrence of any predetermined mechanical condition or by hand, as necessity may arise. This feature is especially useful in connection with crane motors, where, by the use of suitable devices for automatically closing the circuit of the shunt-trip coil, overtravel of the motor-operated hoists may be prevented. The movement of motor-operated draw bridges may conveniently be limited in the same manner. Motor-operated pumps may, by this means, be automatically cut out by using a float-operated switch to bring the shunt-trip feature into operation when the liquid in the tank supplied by the pump reaches the desired height. By similar means the motors operating air compressors may be automatically cut out when the desired pressure is reached.

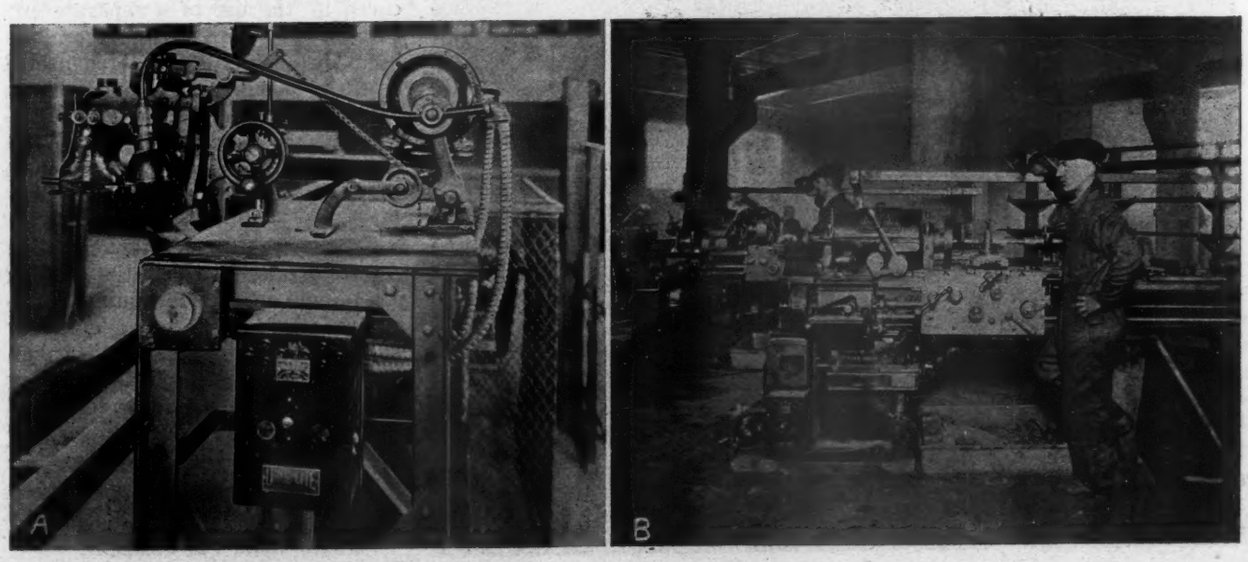


Fig. 7—Two cases where externally operated enclosed breakers are placed conveniently on the driven machine.

At *A* is a small breaker which protects the motor driving a sack-stitching machine. When the motor driving the lathe at *B* trips its breaker on overload, it may be started again at once as the operator does not have to leave his machine to reset the breaker.

Where the material handled by the motor-operated machine is of a readily destructible nature it is often highly desirable that the operator shall be able to cut the power off instantly from any point about the machine under his care. This is made easy by the use of a circuit breaker having a shunt-trip feature with its coil connected into circuit through a number of normally open switches arranged in parallel and so located that one or more of them is at all times within reach of the operator.

Textile factories employing individual motor drive offer an admirable illustration of this class of service. Where each motor is protected by a circuit breaker with the shunt-trip feature the possibility of injury to employees is thereby greatly reduced, as ready means are thus afforded to cut off the power instantly from any machine involved.

Where motor-driven printing presses are employed the destructible nature of the substance handled makes it necessary that the operator shall be able to cut off the power instantly from any point about the press. In particularly exacting work the press is sometimes equipped with switches (in series with the shunt-trip coil) which are automatically closed by any irregularity in the run of the paper or failure to register properly. The prompt stopping of the press thus serves as a check against the production of imperfect work.

Any of these conditions may be taken care of likewise by means of the no-voltage device. The circuit from the no-voltage coil is extended to any points desired. Pushbutton or other switches are inserted in series with the circuit. These switches are normally in the closed position. When one of the switches is opened the current through the no-voltage coil is interrupted and its armature drops and opens the circuit breaker. Where these switches are desired at several points only a single wire need be run through each switch in series and back to the breaker. This method of control is good from the safety standpoint because any accidental open circuit in wiring or switches will cause the breakers to open and thus be brought to the operator's attention.

Two or More Motors Interdependent on Each Other

Where two or more motor-driven machines co-operate in handling the same material it is sometimes of the greatest importance that if one machine of the group becomes inoperative the others also will be put out of service. This condition frequently arises in connection with the motors operating traveling cranes, and coal- and ore-handling machinery. It is present also in certain manufacturing processes where the supply of material for each motor-driven machine depends upon the continued operation of the other machines of the group engaged in fabricating the same material.

Fig. 6 illustrates a circuit breaker which is especially designed for this class of service. In addition to the shunt trip it is provided with one overload coil for each motor of the group and a single switch member, the latter to be connected between the motors and the common source of supply. The result of this arrangement is that an overload on any one of the motors operated through this circuit breaker will cause the disconnection of all of them. In addition the shunt-trip feature affords a convenient means of opening the circuit breaker through hand-operated pushbuttons or by automatically actuated limit or stop devices.

Similar results may also be secured by the use of a separate circuit breaker for each motor, the breakers being so interconnected that the opening of one results in the opening of all. One way of arranging the breakers is to connect the no-voltage coils of one motor to the leads of the next preceding motor in the chain of operations.

Another means of interconnecting circuit breakers so that the opening of one will cause the opening of another, is by the use of an auxiliary switch mounted on the first breaker, as shown in Fig. 9. This auxiliary switch as shown should be connected to the *(Continued on page 563)*

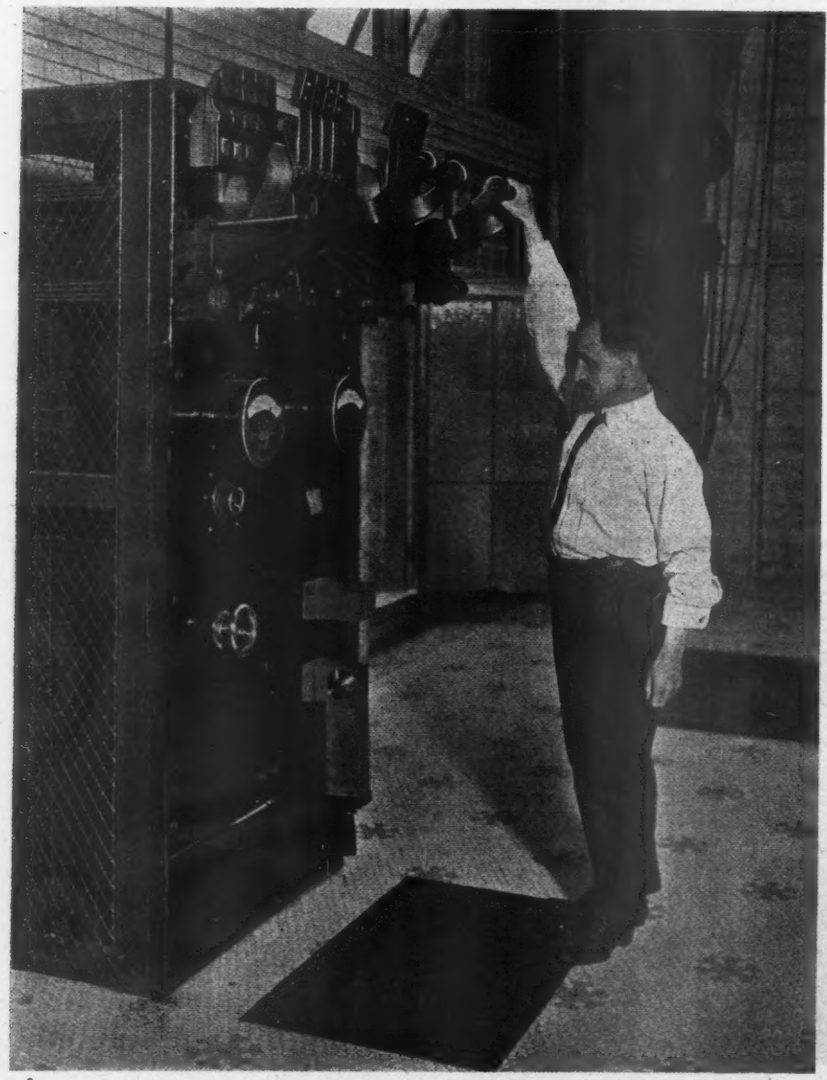
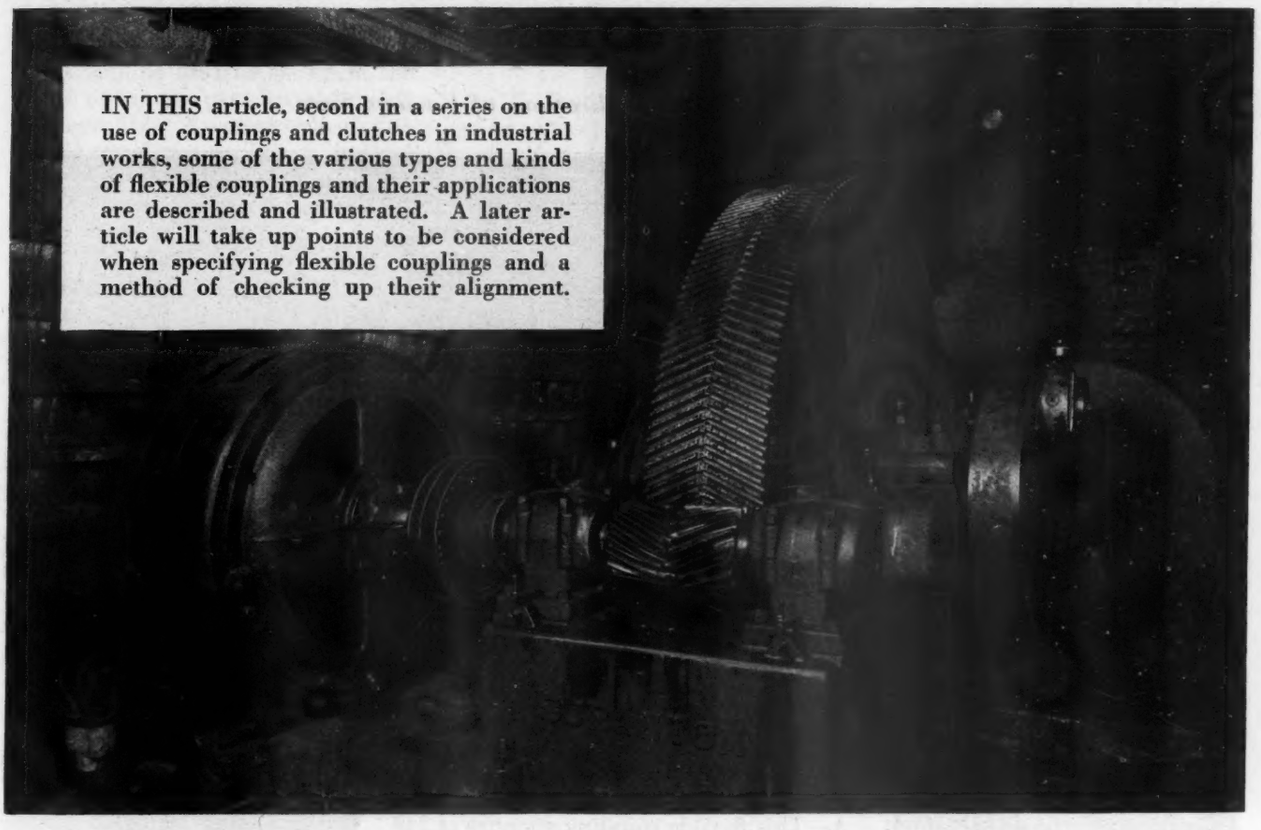


Fig. 8—Circuit breaker on 2,000-kw., 250-volt, two-wire direct-current generator panel in plant of Packard Motor Car Company.



IN THIS article, second in a series on the use of couplings and clutches in industrial works, some of the various types and kinds of flexible couplings and their applications are described and illustrated. A later article will take up points to be considered when specifying flexible couplings and a method of checking up their alignment.

This flexible coupling connects a 450-hp. motor to the pinion shaft of a large plunger pump.

Points to Consider in Using Various

Types and Kinds of Flexible Couplings

To Provide a Non-Rigid Connection Between Shafts of Two Machines

By FRANK E. GOODING
Associate Editor, Industrial Engineer

RIGID flange couplings, which were discussed last month in the first article of this series, would make an ideal connection for two or more large machinery shaftings if it were not for the fact that they are too rigid and make no allowance for slight errors in misalignment or for the errors that come with wear of bearings, settling of frames or foundations, and other operating difficulties. With any misalignment and such a rigidly connected shaft, experience shows that some of the troubles to be expected are: Excessive shaft binding, loss of power through friction, excessive wear of bearings, difficulty of lubrication, and sometimes even broken shafts or couplings. Direct connection of machines is often very desirable and as a result various types of flexible couplings have been developed to fill this need, especially for high-speed operation.

Perfect alignment, if it were possible to be attained and kept, would be ideal. Builders of high-speed, direct-connected machinery such as turbines, line up shafts to within 0.003 or 0.004 in. On slower-speed machinery a greater allowance is usual and permissible. Hardly ever, however, on ordinary equipment does the misalignment exceed $\frac{1}{16}$ in. Continuous drives such as rolling mills and similar metal mill equipment are, of course, excepted in this statement.

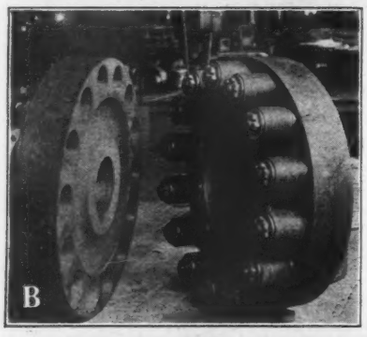
Misalignment, however, should not be permitted to continue but should be located by frequent check-ups on alignment and corrected. One of the most common complaints on flexible couplings arises from a mistaken belief that they will take care of any misalignment and do not need any attention after once installed. They do take care of a certain amount of misalignment, but operate much more satisfactorily, both as to the coupling and as to the machines, if maintained as nearly in perfect alignment as possible. It is not the function of a flexible coupling to compensate for careless or incompetent erection, nor for lack of reasonable maintenance attention.

Misalignment may be either: (1) Parallel, that is, shafts parallel but out of center. (2) Angular, that is, with shafts in center but out of line. (3) A combination of both, with shafts out of line and also out of center. A misalignment made up of a combination of both types is probably the most common. When it is necessary to provide for

Examples of Flexible Coupling Installations

Seven Typical Industrial Applications of Various Sizes

A


B

C

A—This flexible coupling operates at 240 r.p.m. between a 2,500-hp. motor and the pinion driving a steel mill.

B—A flexible coupling of the bushing type with flanges 40 in. in diameter.

C—Here the flexible coupling is placed between an 80-hp. steam turbine, operating at 450 r.p.m., and the reduction gear, driving a forced-draft fan.

D—The circumference of the flange is cut with sprocket teeth and tied together by a chain on this engine drive to a ventilating fan.

E—A close-up view of a large universal-joint type of flexible coupling used in steel mill work.

F—Here a pair of universal-joint type of flexible couplings are shown driving a 40-in. blooming mill at the Weirton Steel Company.

G—Four universal couplings of various sizes are used on a paper mill.

D

E

F

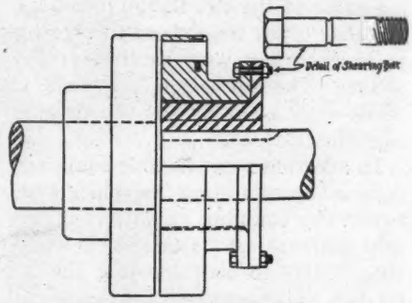
G

the possibility of excessive misalignment, two couplings connected by a shaft may be used as shown in the upper of the two sketches at the left on page 532. A connection of this sort is sometimes used on rolling and blooming mills. For ordinary work this intermediate shaft is shortened down to a collar or floating ring as shown in the lower of these two sketches reproduced at the left of the page.

Rough Classification of Types of Flexible Couplings

There is a large variety of flexible couplings, many of which have special limitations as to size or the purpose for which they may be used. In general, they may be divided into: (1) Semi-flexible; (2) flexible; (3) universal joint.

In the classification of semi-flexible couplings are: (*a*) The familiar "Oldham" coupling which consists of two flanges, in each of which a keyway is cut across the face at angles of 180 deg. to each other with a central piece or disk having projections integral with it to fit into the cross keyways. (*b*) A flange coupling with pins solid in one flange and with clearance holes in other flange to receive pins, or the pins and clearance holes may be alternately arranged in both flanges. (*c*) Numerous other similar types and modifications which give flexibility of movement in but two directions except as looseness of parts may give flexibility in the third direction.



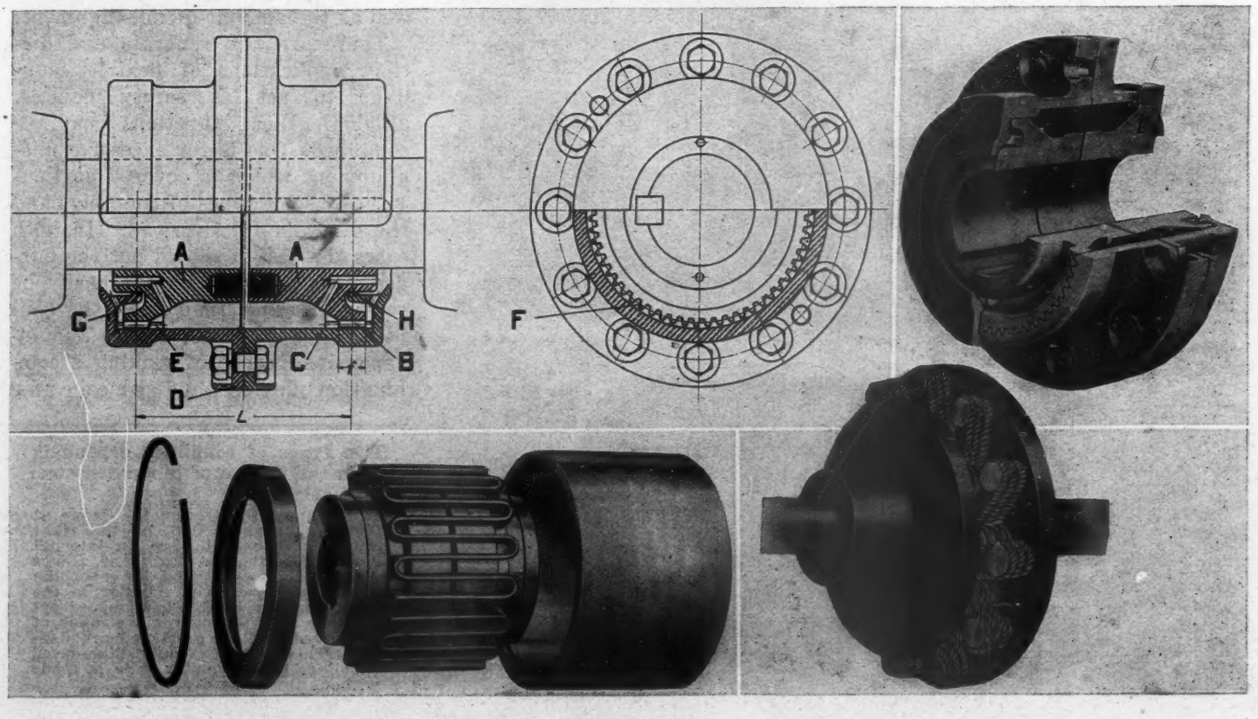
One method of putting a safety link into a flexible coupling.

Flexible couplings must be safeguarded against both overload and excessive misalignment. In case excessive misalignment may be expected a special type of coupling should be used. A shearing pin takes care of overloads.

Semi-flexible couplings are usually used on light-duty work or on low-speed work where it is intended that the coupling will accommodate some slight difference in the endwise location of the two shafts rather than any movement after the shafts are in operation. If there may be any running misalignment it is usually found that such semi-flexible couplings are noisy and wear quickly. Most of these were among the earlier developments of flexible connections and are not so generally used for high-speed or heavy-duty work as are the newer types of flexible couplings.

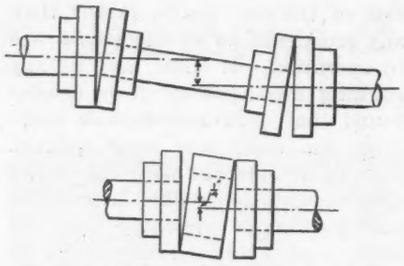
The classification of flexible couplings comprises: (*a*) A flanged coupling with pins solid in one flange and with clearance holes in other flange to receive bushed end of pins. This is similar to the type (*b*) of semi-flexible coupling except that the pins are bushed with rubber, leather, fiber, or other similar material which permits a certain degree of flexibility. Frequently a metal bushing is placed around the pin to decrease the wear on the rubber or fiber bushing. (*b*) A coupling with projecting pins which are staggered and alternate on each flange and are connected with laced leather belts, rope, wire, or other material. (*c*) The coil spring coupling. (*d*) All-metal type couplings. (*e*) Such types as combine sliding movement and looseness of parts. (*f*) Types which combine sliding movement and flexure of materials.

The bushed-pin is a common type of flexible coupling. In the smaller sizes this construction is inexpensive and while the bushings may need to be replaced often it is easily done



Three other well-known flexible couplings.

The three views at the top show a coupling which virtually consists of flanges with gear teeth cut in the circumference and meshing into a case containing internal teeth. This then operates with a self-aligning action somewhat similar to the self-aligning principle of bearings. As these teeth mesh in an oil bath the wear is slight and the coupling may be used in either forward or reversing motion. In the coupling in the lower left corner of the illustration the two half-flanges are tied together by tempered steel springs. The grooves in the flanges widen inward toward each other so that the spring fits closely in them only at the outer ends and so permits flexibility. The entire coupling is covered by a shell and operates in grease. The projecting pins on the two flanges in the coupling at the lower right are fastened together by an endless rope. This has a wide range of flexibility and is commonly used on blowers and exhausters.



Two methods of taking care of parallel misalignment.

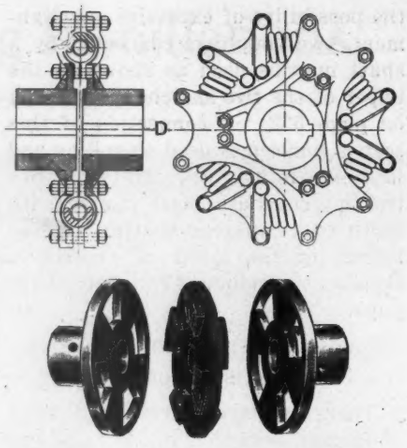
Where parallel misalignment is apt to be large, as in the upper illustration, a pair of couplings connected by a shaft may be used, particularly in rolling mills were couplings similar to universal joints are frequently employed. Where this misalignment does not exceed ¼ in. the shaft may be reduced to a collar about 13 in. long, as shown in the lower sketch.

and the cost is low. Sometimes the bushings are made of bronze in which case this type of coupling approaches the semi-flexible type with the pins and clearance holes as previously mentioned. Flexible couplings made with the flanges interlocking and using buffers of rubber or leather are of a similar type. Still another type of construction is made by recessing the flanges of the couplings and placing between these flanges a disk having leather or rubber lugs on it to fit into the flanges.

In some all-metal types of flexible couplings coil springs are used to join the flanges either in compression or in tension between interlocking arms of the two flange members. In other types the axis of the spring is in the same axis as that of the shaft. The operation of these is made more clear by the accompanying illustrations.

In addition some flexible couplings depend upon sliding movement between the coupling parts and a certain amount of looseness between these parts to accommodate the intended movement of the coupling. The "wobbler" type of coupling used for slow-speed work in rolling mills is a modification of this. Another type of coupling consists of flanges with sprockets on the circumference and with a chain loosely wrapped around the sprocket piece. Instead of the chain still another type of coupling uses a solid ring with internal teeth to mesh with the teeth on the external sprocket, as is shown in the cut on page 531. These teeth are filled with a lubricant to minimize the wear and as they are closely cut and meshed they may be operated in either direction, and, it is claimed, under reversing conditions.

Where sliding movement and flexure of materials is used to obtain the required flexibility for a given degree of misalignment, the life of the coupling is claimed to be longer than with rubber or fiber parts and with some types it is usually easy to replace the wearing parts.

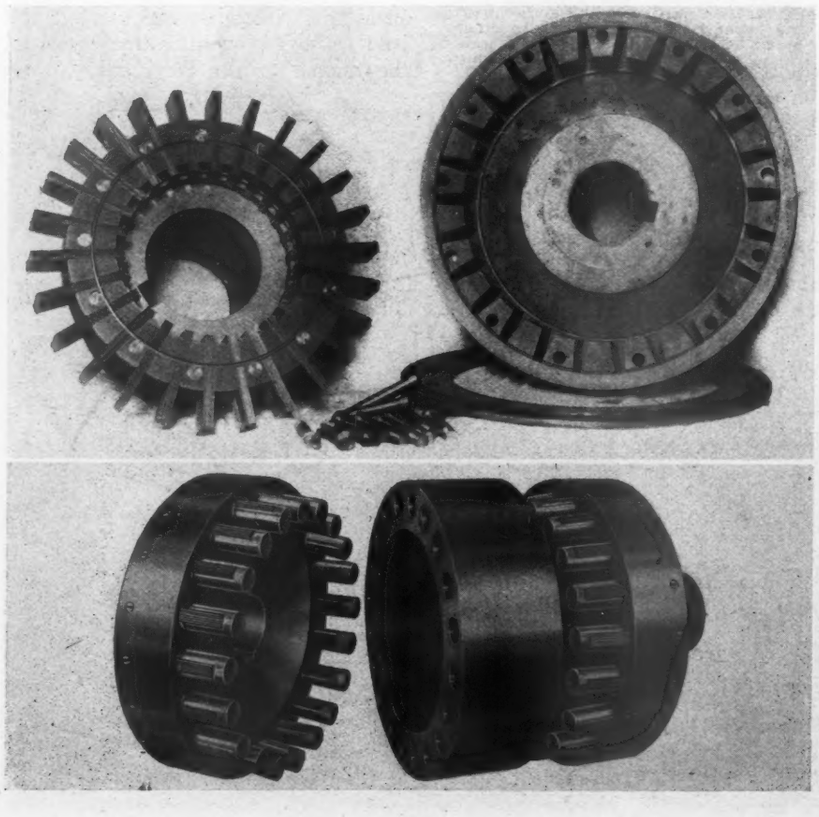


Two well-known flexible couplings.

In the upper coupling springs supply the necessary resiliency and flexibility. In other similar couplings rubber or other material is frequently used. The lower coupling uses a leather disk with projections which fit into recesses in the flanges.

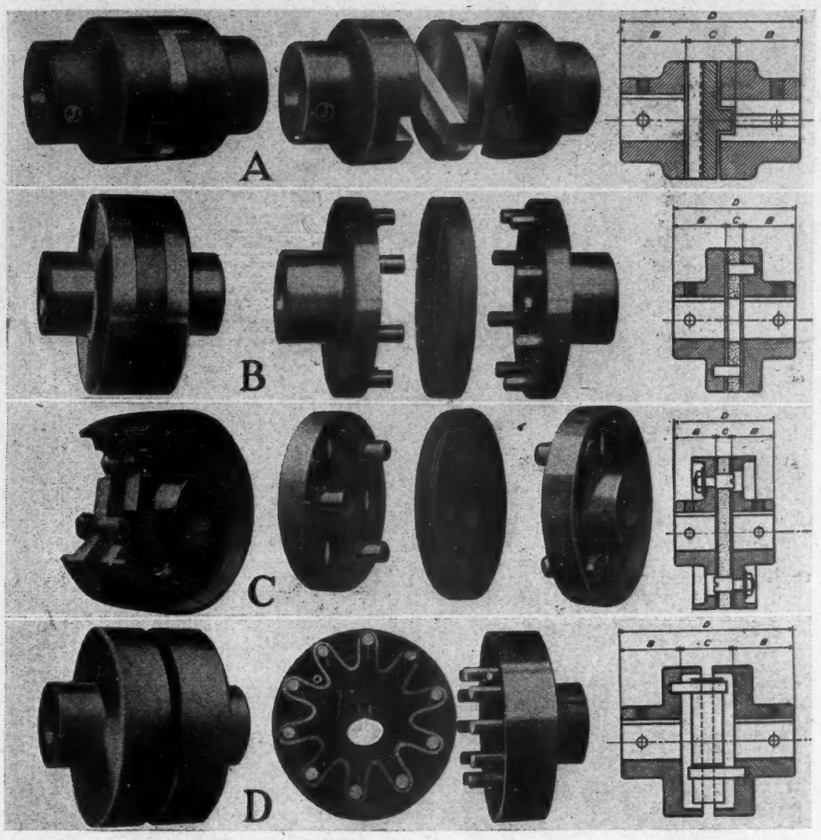
In some cases, such as where it is necessary frequently to change armatures in emergency repair work, as in steel mills, some of these types of couplings are more easily dismantled than are others. Where such conditions are anticipated a half-coupling is usually fastened onto the spare armature shaft and the shift made with but little delay. In other types where the rubber or other resilient material must be renewed occasionally, some types are so designed as to be more convenient for disassembly and renewal. The frequency of this renewal varies according to the abuse, the amount of use, and the resilient materials used, as well as the amount of misalignment.

There are two separate and distinct applications of flexible couplings to act as safety devices, although these functions may be combined. One is for excessive misalignment which is covered particularly by some types of couplings and the other is for overload. In both cases the design should put the burden upon parts which can easily be replaced rather than upon the connected machines. A simple and inexpensive method of making a combination flexible and shearing



Two types of couplings depending upon the flexure of laminated steel segments.

In the upper illustration the flange at the left fits into that at the right, much as though it were an internal gear. This absorbs shock and allows for misalignment. The lower of the couplings is somewhat similar to the solid pin type flexible coupling except that the pins themselves are made of laminated steel sections and are flexible. This is a heavy duty, high-speed coupling, but a similar type is made without the central section.



Here are four common types of flexible couplings.

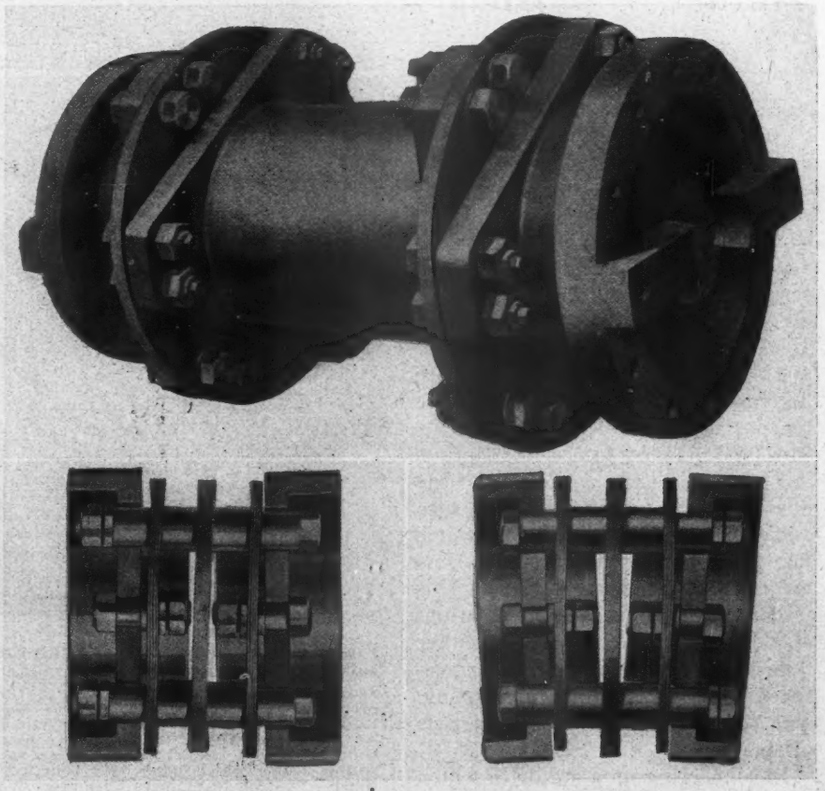
(*A*) This is an all-metal coupling with the flanges of cast-iron and the floating center piece of steel. This is of the "Oldham" type of semi-flexible coupling and is suitable for operation under heavy loads at slow speed and may be used for reversing service. (*B*) A coupling of the bushed-pin type where the pins fit into a fiber disk. The holes in the disks are slightly larger than the pins, which permits the coupling to automatically adjust itself for misalignment. It is commonly used for connecting motors, as it allows some endwise movement. (C) In this bushed-pin coupling a leather disk is used. The pins may be removed and the disk replaced without taking the coupling from the shafts or moving the connected machines. These bushed-pin couplings are not intended for low speeds or heavy torques. (*D*) In this coupling the steel pins are connected by special oil-treated endless leather belts. These are extremely flexible, absorb shock and vibration and are suitable for either high- or low-speed drives.

coupling is shown in the sketch on page 531, where one flange of the flexible coupling is loosely mounted on the hub of a flange which in turn is keyed to the shaft. This solid flange is bolted to the flange of the flexible coupling by bolts which have a reduced section as indicated.

In case of excessive overload of a predetermined amount, the bolt or bolts will shear before any serious damage is done to the connected shaft and the solid coupling will run free within the flexible coupling. After the trouble has been corrected new bolts are installed and the drive is again ready to run, at a negligible cost for new bolts and the shortest possible delay in production. This design also lends itself to the very quick change-over for a new rotor for one which may need repairing, or change for other purposes.

There is still another type of flexible coupling which in an analysis of its construction most closely resembles a universal joint. Most of these are constructed upon some modification of the original "Hooks" idea of one pair of fingers joining through a pair of pivot points and a block with another pair of fingers at right angles to the first one. Another type, shown below, consists of a number of fingers of one coupling member fastened at the end to a fiber or metal disk and alternately joined to the fingers of another shaft member on the other side of such disk. Both types are sometimes used on blooming and rolling mills where a large amount of power is transmitted at a large and varying angular misalignment.

These couplings are usually used to transmit *(Continued on page 564)*



A large and small unit of one manufacturer.

The upper coupling weighs 14 tons, has a capacity of 10,000 hp. at 100 r.p.m. and is installed at one of the plants of the Brier Hill Steel Company, Youngstown, Ohio. It provides for a parallel misalignment of ½ in. and endwise float capacity of 1 in. Here a central member is interposed between two end flanges and is connected to these flanges by laminated flexible steel disk rings which in turn are bolted alternately to the center member and end flanges. The two lower illustrations show a coupling of similar make built for high-speed service, as it operates under parallel and angular misalignment.

IN THE SEPTEMBER issue of INDUSTRIAL ENGINEER a series of articles was started by Mr. Roe on laying out and checking up winding diagrams of induction motors. The second article in the October issue dealt with the checking up of three-phase windings when using short and long jumpers with star, delta and other connections. This article takes up the actual work which a repairman does with his hands and tools in making winding connections after he has checked up the diagrams and determined what connections to make. This series of articles should be used in connection with other articles by Mr. Roe which have appeared in issues previous to September of this year, on connections which are possible when making changes in induction motor windings.

Detailed Directions for

Stubbing and Connecting Windings

Of Induction Motors And an Explanation of Some Two-Voltage Windings

By A. C. ROE

Repair Superintendent, Detroit Service Department, Westinghouse Electric & Manufacturing Company

ARTICLES by the writer that have appeared in INDUSTRIAL ENGINEER on connecting induction motor windings have referred for the most part to the diagrams that represent the windings. This article takes up the actual work which the repairman does with his hands and tools when connecting the motor. It tells how to stub the coils and how to locate and put on the jumpers between groups and the line leads. In addition there is also an explanation of windings which may be reconnected outside the motor for two different voltages. This is done by changing the connections of the external leads. Still another type of special winding, the two-speed and the four-speed winding, will be discussed in a later article in this series.

In connecting up a stator in which

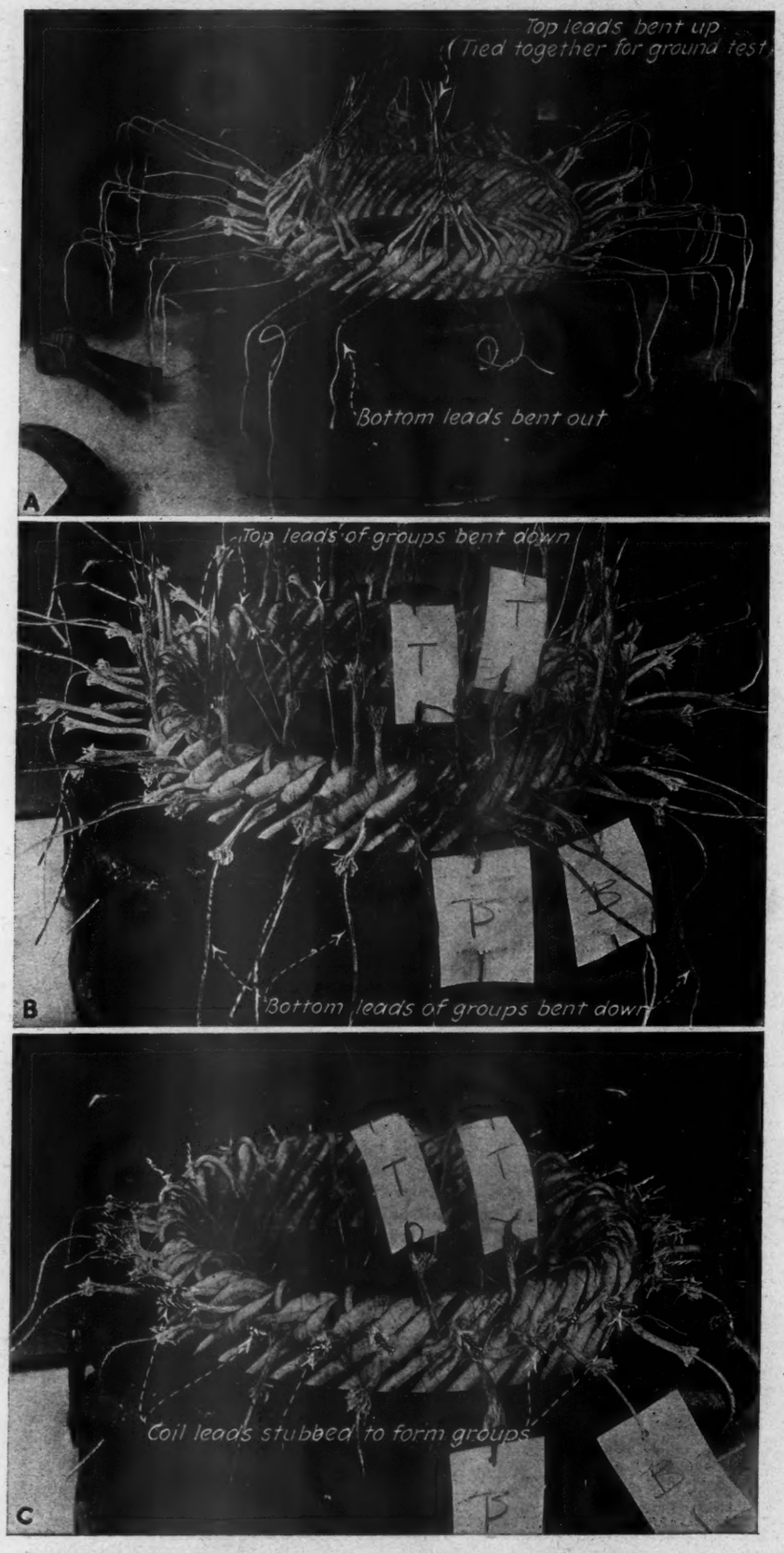


Fig. 1—Three steps in connecting the coils of a stator winding.

See Fig. 2 for three later steps in the process. This winding employs the coil leads for jumpers as well as for stubs. At *A* the top leads of the coils have been bent upward to separate them from the bottom leads, which have been bent outward. The top leads have also been tied together temporarily with copper wire preparatory to making a ground test. At *B* the leads which will be used as group leads have been separated from the other leads by being bent down, the top leads inside the stator and the bottom leads outside. At *C* the coils have been stubbed by twisting the leads together to form groups. With heavy-wire coils sleeves may be used in making stub connections.

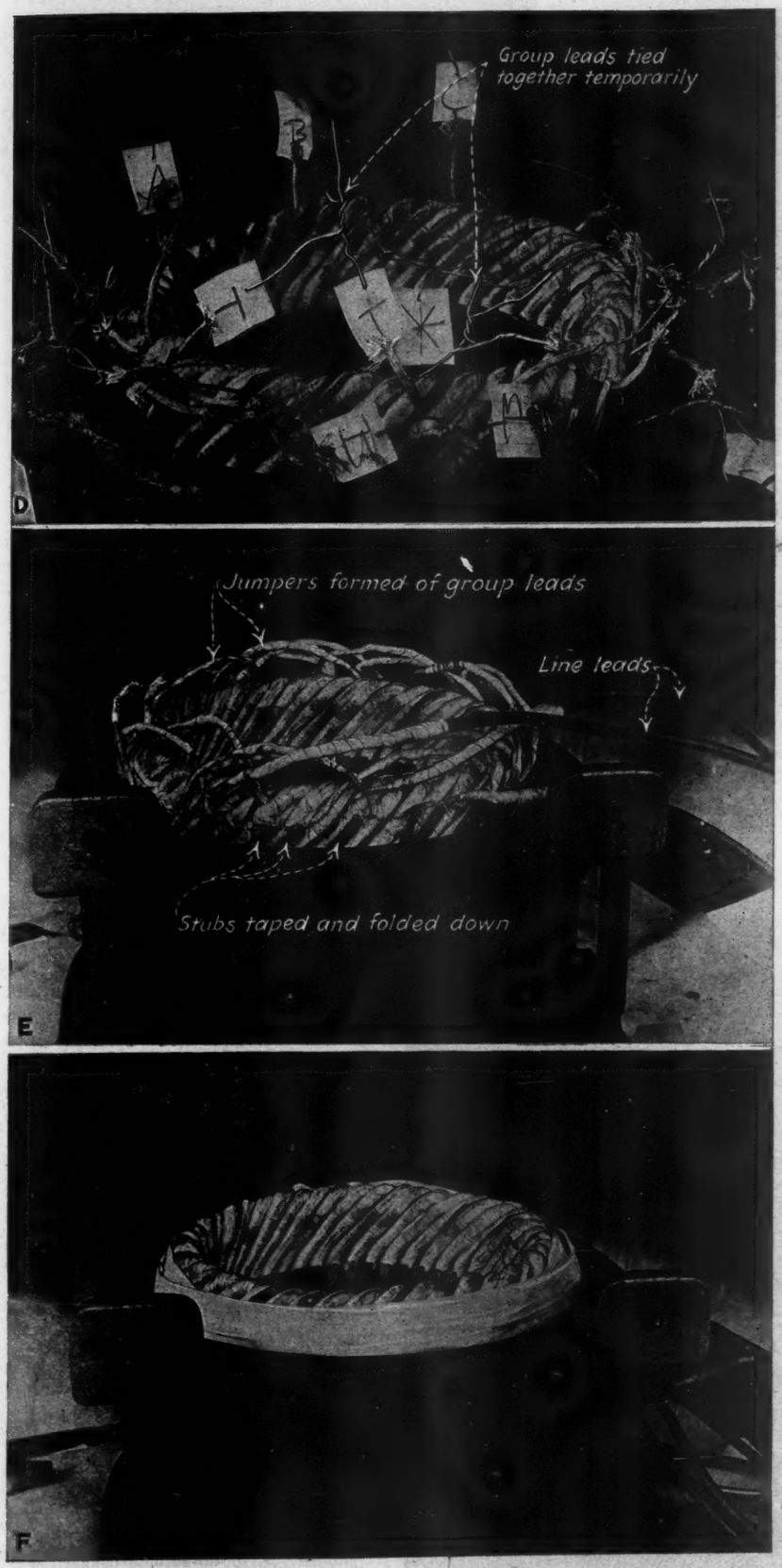


Fig. 2—Three later stages in connecting an induction motor.

Three earlier steps are shown in Fig. 1. At *D* the stubs have been insulated with tape and folded down. Where there is plenty of end room it is preferable to leave the stubs standing up as shown in Fig. 3. After the stubs are folded down in *D* the leads which form the jumpers are temporarily twisted together. They are afterwards connected by a Western Union joint and taped. Then the line leads are put on, as shown in *E*. The jumpers are then laid down and bound against the coils with cotton tape, as shown in *F*. The stator is then ready to be baked and dipped in clear varnish.

all the coils are in place, the first step is to separate the bottom leads from the top leads; then the coils are tested for grounds. After this the group leads are located, the coils in the groups are stubbed together and finally the jumpers between groups and the line leads are put on. The top leads are separated from the bottom leads as shown in *A* of Fig. 1. The top leads are bent upward while the bottom leads are bent outward. Then all the top leads are temporarily tied together after the insulation has been scraped off the ends. A convenient type of lead scraper is shown on the bench in *A* of Fig. 1. The leads are all tied together with a piece of bare copper wire which is put on tight enough to make good electrical contact with all leads. For making the ground test, an alternating-current testing transformer is used, one test lead being attached to the copper tie wire and the other lead to the motor frame. The voltage used in the test should be equal to twice the name-plate rating of the motor, plus 1,000 volts. For instance, a 220-volt motor would receive 1,500 volts. After this voltage has been held on for one minute without the breakdown of any coils, the insulation may be considered satisfactory.

The next step is to determine which are the group leads. When there is extra insulation between the phases, the position of the groups will have already been laid out and the group leads will be already determined. This extra insulation between the phases may consist of what are called phase-coils, which are covered with extra-heavy insulation and are put at the ends of groups. Another way in which this extra insulation may be furnished is by varnished cambric inserted between the groups while putting the coils in the slots. Fig. 1 shows insulation of this kind inserted between groups. Where such insulation is used, the group leads are found on each side of each piece of insulation.

On the other hand, if all the coils are insulated in the same way and there is no added insulation between groups, the position of the group leads must be determined. The method of determining the position of the group leads and the number of coils per group, and so on, was explained in the March, April, May and June, 1923, issues of INDUSTRIAL

ENGINEER. Suppose, for instance, that we have an armature with fifty-four coils, all of which are insulated in the same way and there is no extra insulation placed between phases. If this is a three-phase, six-pole machine, there will be three coils per group. Then select a top lead and bend it down into the stator. Photograph *B* of Fig. 1 shows how the top leads are bent down. Count over to coil 3 (calling this first coil, coil 1); then bend the bottom lead of coil 3 downward towards the frame, thus forming one pole-phase group of three coils. The top lead of the next group, which is the top lead of coil 4, starts the second group and this is bent down. The bottom lead of coil 6 ends this group and this also is bent down. This process is repeated entirely around the winding until all the groups are formed.

Some winders use the number of coils per group as a lead pitch and pass around the machine twice, picking out all the top leads on the first round and the bottom leads on the second round.

After the group leads are picked out, the coils in each group are connected in series or stubbed. Ordinarily this is done by twisting the coil leads of the adjacent coils together. The top lead of one coil is connected to the bottom lead of the next coil. Photograph *C* in Fig. 1 shows how the coil leads are twisted together. The stubs are then wrapped with friction tape. After the stubs have been insulated they can, if the end room is scarce, be bent down and laid in the spaces between the diamond points of the coils, as shown in *D* of Fig. 2. When there is plenty of room, however, it is best to leave the stubs standing up, as shown in Fig. 3.

When the coils are made of stiffer wires, it is sometimes preferable to use sleeves for making the stub connections, instead of twisting the wires together. One type of sleeve is that shown in photograph *B* of Fig. 4. Another type is shown in Fig. 5. Fig. 4 shows a 4,600-volt, three-phase, eight-pole, 96-coil machine with four coils per group. In making up the coils, twenty-four of the coils have extra long top leads, and twenty-four extra long bottom leads. These are then placed in the stator, as shown in *A* of Fig. 4. The long coil leads are afterwards used for jumper connections. The stub connections are formed as in *B*. A small loop is left so that the stubs can be well insulated. They are taped with four half-lapped layers of varnished-cambric tape, each layer being brushed with clear baking varnish to fill in the pinholes caused by stretching the tape. After this they are wrapped with cotton tape, as shown in *C*.

In Fig. 5 is shown another type of connection used for stubbing and jumper connections, where very heavy wire is employed. These connectors are formed of sheet copper and consist of two round holes into which the wires slip, these being connected together by a cross piece of copper.

Insulation Needed on Low- and High-Voltage Motors

Voltage of Motor	Insulation To Be Used
110-220...	Stubs: one layer friction tape. Jumpers: one layer treated-cloth tape and one layer friction tape.
440-550...	Stubs and jumpers: one layer treated-cloth tape and one layer cotton tape. Fill tape with good baking or air-drying varnish.
1,100-2,300-4,600.....	Make stubs in loop form; insulate all joints with four half-lapped layers of treated cloth. Brush each layer with clear, amber baking or air-drying varnish. Afterward put on one layer cotton tape and fill with varnish as above.

How the Jumpers Are Put On

After the coils have been stubbed, the line and the star leads must be selected. If this winding has unequal grouping of coils the line and the star leads must be determined when the coils are divided into groups. If all the groups are equal, we may take either top or bottom leads for the line leads. In the case of Fig. 1, all top leads are used. Any top lead may be selected near the point where the leads pass through the motor frame. Call this lead a line lead and mark it with a tag, as shown in *D* of Fig. 2, or twist the wire so it may be identified later. The leads are then temporarily connected together by twisting as shown in *D* of Fig. 2. In a top-to-top connection, using short jumpers, as shown in Figs. 1 and 2, the short lead will be on the fourth

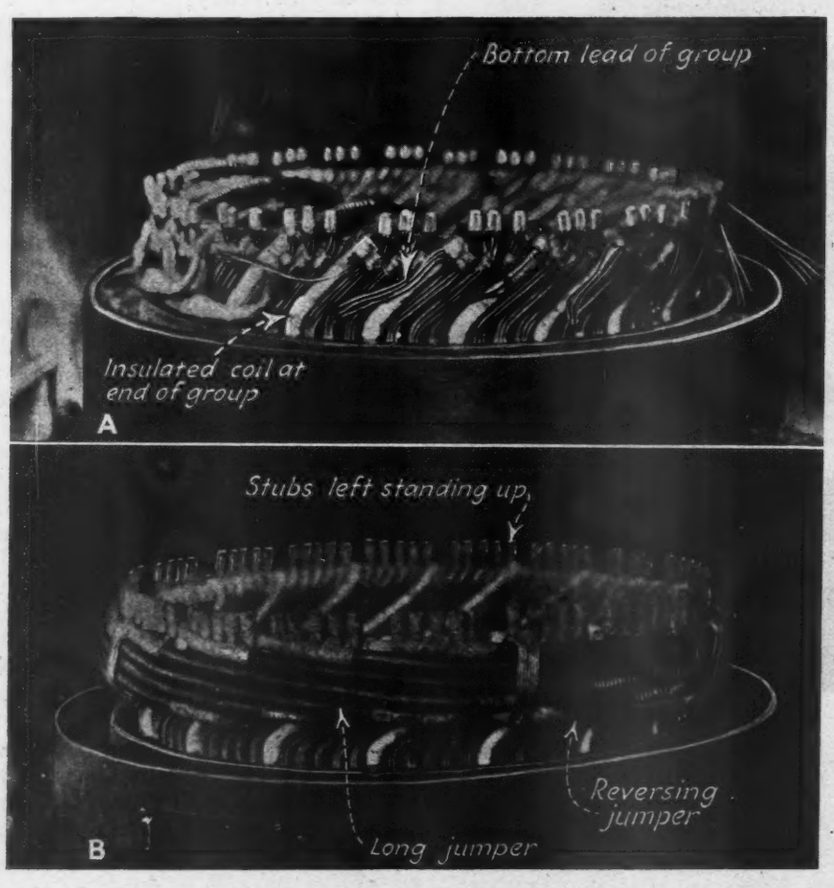


Fig. 3—Cable used for long type of jumper.
This shows the neat appearance which may be obtained when using the long jumper or top-to-bottom connection. The jumpers are rubber-insulated, stranded wire. The top connections are all made first, some of which are shown in *A*. Then all the bottom connections are made. The jumpers are tied together with cord at intervals, as shown at *B*. The stubs on these windings have been left standing up. It will be noted that the windings in *A* and *B* are not the same, although they are of the same kind.

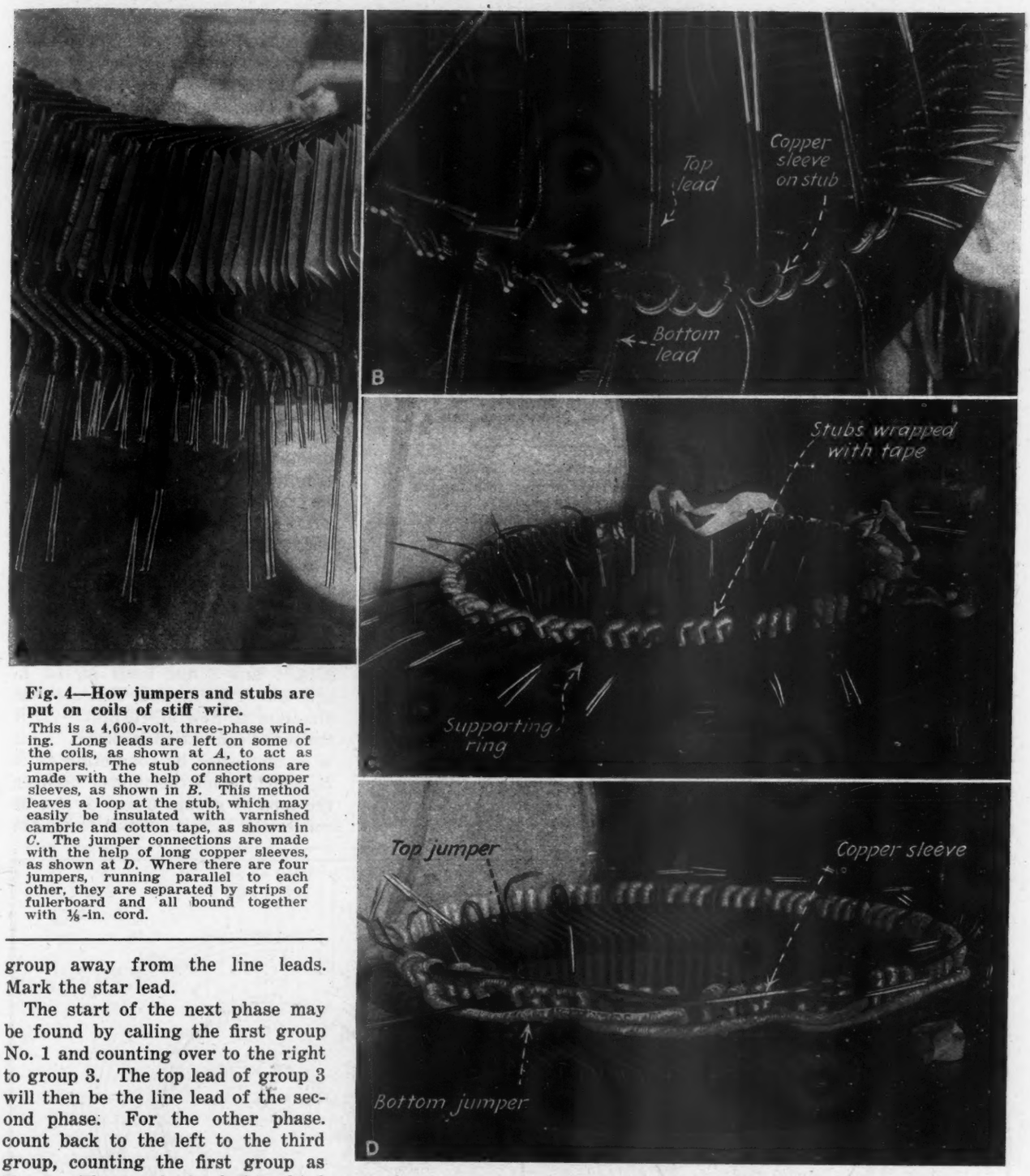


Fig. 4—How jumpers and stubs are put on coils of stiff wire.

This is a 4,600-volt, three-phase winding. Long leads are left on some of the coils, as shown at *A*, to act as jumpers. The stub connections are made with the help of short copper sleeves, as shown in *B*. This method leaves a loop at the stub, which may easily be insulated with varnished cambric and cotton tape, as shown in *C*. The jumper connections are made with the help of long copper sleeves, as shown at *D*. Where there are four jumpers, running parallel to each other, they are separated by strips of fullerboard and all bound together with ⅛-in. cord.

group away from the line leads. Mark the star lead.

The start of the next phase may be found by calling the first group No. 1 and counting over to the right to group 3. The top lead of group 3 will then be the line lead of the second phase. For the other phase, count back to the left to the third group, counting the first group as No. 1. The top lead of this third group will then be the line lead of the third phase. See photograph *D* in Fig. 2. This shows the three line leads which have been marked with paper slips and also the star connection which has been temporarily tied together and marked.

After these line and star leads are determined, the groups are connected in series. For the short-jumper type of connection the bottom lead of group 1 connects to the bottom lead of the fourth group to the right. Then the top lead of the fourth group will connect to the top lead of the fourth group to the right again. Continue this until the star lead is reached and repeat the same proceeding for each phase. Some winders connect all the bottom leads and solder and tape the connections and lay these jumpers in place. Then the top leads are connected and laid down on top of the bottom jumpers. This is called putting the jumpers down in two layers. When using small-wire coil leads for jumpers, employ the Western Union splice and solder each connection. Then tape the joint with one half-lapped layer of varnished-cambric tape and one layer of cotton tape. It is well to stick the ends of the cotton tape down with a little shellac to keep them from unwinding. Photograph *E* of Fig. 2 shows the jumpers of this machine all connected and taped. The leads also have been attached. In photograph *F*, Fig. 2, the leads and jumpers have been laid down and a few turns of twine have been

applied to bind them together. The stator is next balanced out.

Then the stator is baked for four hours, at 212 deg. F., and dipped, while hot, in clear baking varnish to make the winding moisture-proof and oil-proof.

In case the coil leads which are used for jumpers are of heavy wire, copper sleeves may be employed as shown in *D* of Fig. 4. These long copper sleeves are put on and soldered and then the jumpers are insulated with a layer of half-lapped varnished-cambric and cotton tape. It may be noted that at some points there are four layers of jumpers. After the jumpers are all in place and insulated, treated fullerboard spacers are put between the jumpers at each point where there are four layers and the four are then tied together with a twelve-turn, ⅛-in. mason's cord band.

Fig. 3 shows an example of the long type of jumper. Note that in both *A* and *B* only one coil per group is insulated. This is the starting coil of each group. In some cases two coils per group are taped, in order to insure extra insulation between phases. Flexible cable is used for the jumpers in this winding. One jumper is made as a sample of the required length for the long jumpers and then the desired number of jumpers is cut. Both ends are skinned and tinned, after which they are attached to all top leads and soldered and taped. The jumpers are then bent into place and connected to the bottom leads, as shown in *B*. The long-jumper connection of this kind makes a very neat job.

Fig. 5—Copper connectors used for stubs and jumpers on heavy wire.

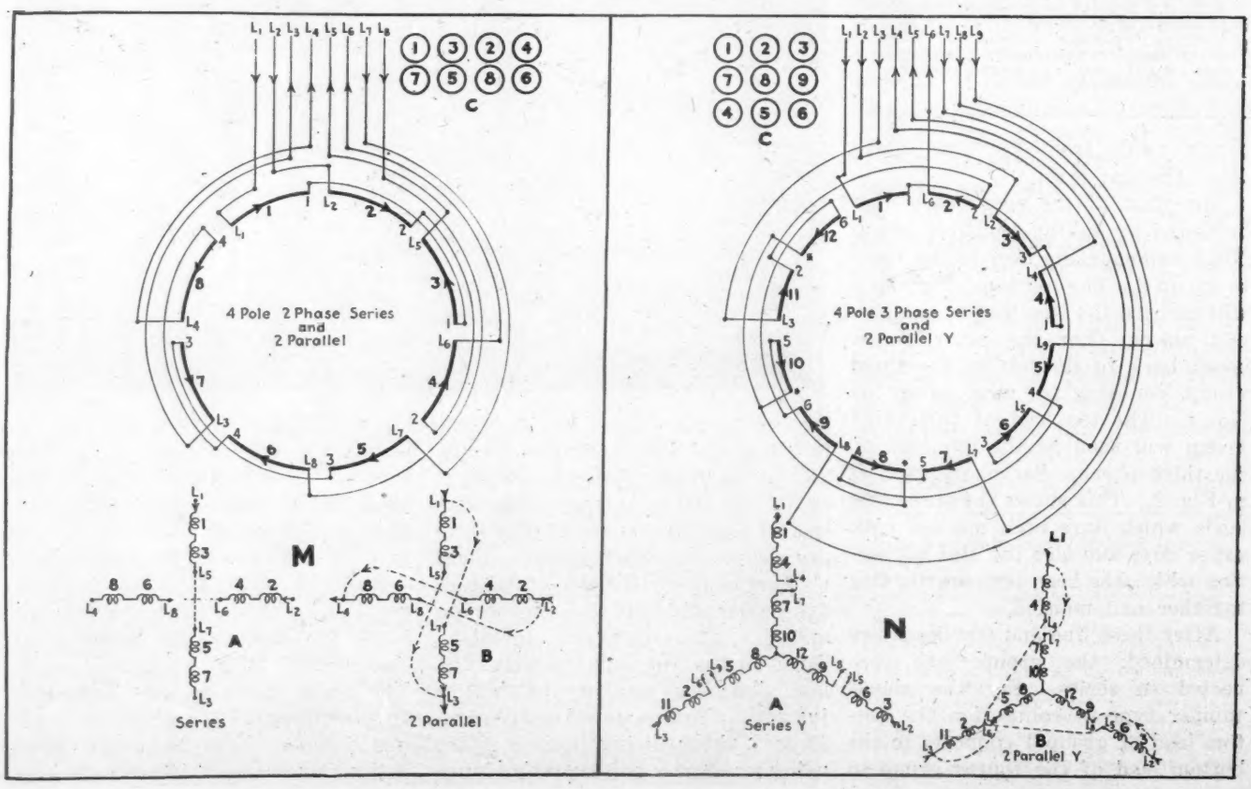
Fig. 6—Windings which may be connected outside the motor for two voltages.

The small diagrams *A* and *B* show how the series and the two parallel connections are made. The small circles at *C* show how the leads may be brought out to avoid crossing of leads outside the motor. For the two-phase, four-pole winding shown at *M* the series arrangement shown at *A* is obtained by making the following connections: *A*-phase lines to L_1 and L_3; *B*-phase lines to L_2 and L_4; L_5 to L_7; L_6 to L_8. The two-parallel connections shown at *B* are: one *A*-phase line to L_1 and L_7; the other *A*-phase line to L_3 and L_5; one *B*-phase line to L_2 and L_8; the other *B*-phase line to L_4 and L_6. For the three-phase, four-pole star winding at *N* the series connection shown at *A* requires that the line leads connect respectively to L_1, L_2 and L_3; L_4 to L_7; L_5 to L_9; L_6 to L_8. For the two-parallel arrangement shown at *B* connect one line lead to L_1 and L_7, the second line to L_2 and L_8, the third line to L_3 and L_9, and L_4 to L_5 to L_6.

How to Connect Windings for Two Voltages

There is a number of two-phase and three-phase motors that have the windings so connected that eight leads are brought out on a two-phase motor and nine on a three-phase. This is done to enable a quick change in voltage.

Drawing *M* in Fig. 6 shows a four-pole, two-phase diagram with eight leads. The object of this type of connection is to divide each phase into two sections, bringing out four leads, two from each section. Then the sections can be connected in series or in parallel outside the motor in a short time. In the small drawings, *A* and *B*, the schematic diagrams for these connections are given. Leads L_1, L_3, L_7 and L_5 form one phase with groups 1, 3, 5 and 7. The other phase consists of groups 2, 4, 6 and 8 and leads L_2, L_8, L_6 and L_4. The arrows indicate the direction of flow of current. At *A* the series connection is shown. This is accomplished by connecting L_6 to L_7, which forms the jumper between the tops of groups 3 and 5, and by connecting L_6 to L_8, which forms the



jumper between groups 4 and 6. The two phases are not interconnected in any way. At *B* the parallel connection is shown. In this case L_1 and L_7 are connected to one line lead and L_8 and L_2 to the other line lead of this phase, thus putting groups 1 and 3 in parallel with groups 5 and 7. The other phase is similar. At *C* is shown one method of arranging the line leads at the motor terminal block to avoid crossing of outside connections.

At *N* in Fig. 6 is shown a three-phase star connection with nine leads brought out, there being three leads from each phase. In this diagram the ends of the second section of each phase are connected together inside the motor to form a permanent star. The schematic diagrams are shown at *A* and *B*. Note that the first section of each phase has two leads. At *B* the two-parallel star schematic diagram shows that L_4, L_5 and L_6 are all three connected together to form the second star connection but the two star connections are not joined together. This failure to join the two stars has no ill effects on the operation of the motor. Drawing *C* shows the way the nine leads are arranged for the least crossing when making external connections.

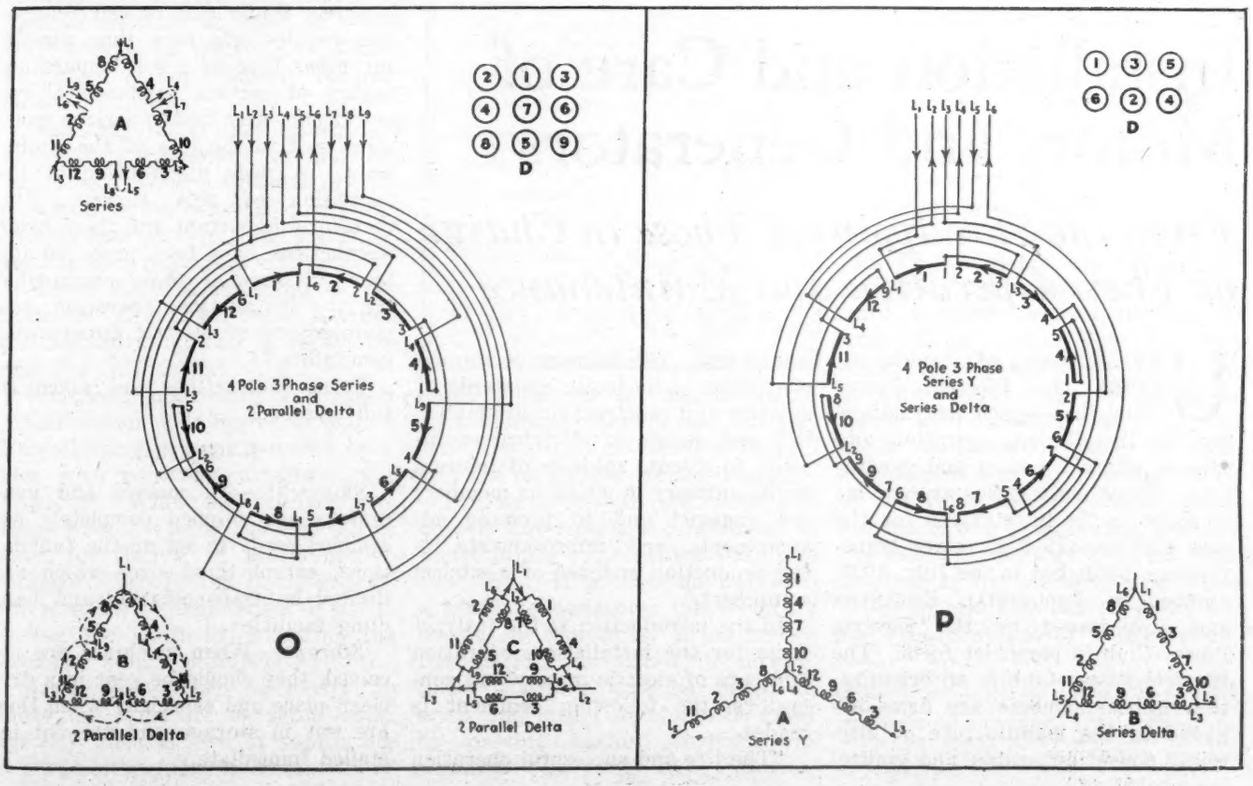
At Fig. 7 is a winding for series and two-parallel, three-phase delta connections, using nine leads. Each phase is divided into two sections as in the previous two cases, but in this diagram there are three leads that have two connections, L_1, L_2 and L_3. Each one of these leads has the beginning of a phase and the ending of a phase attached to it.

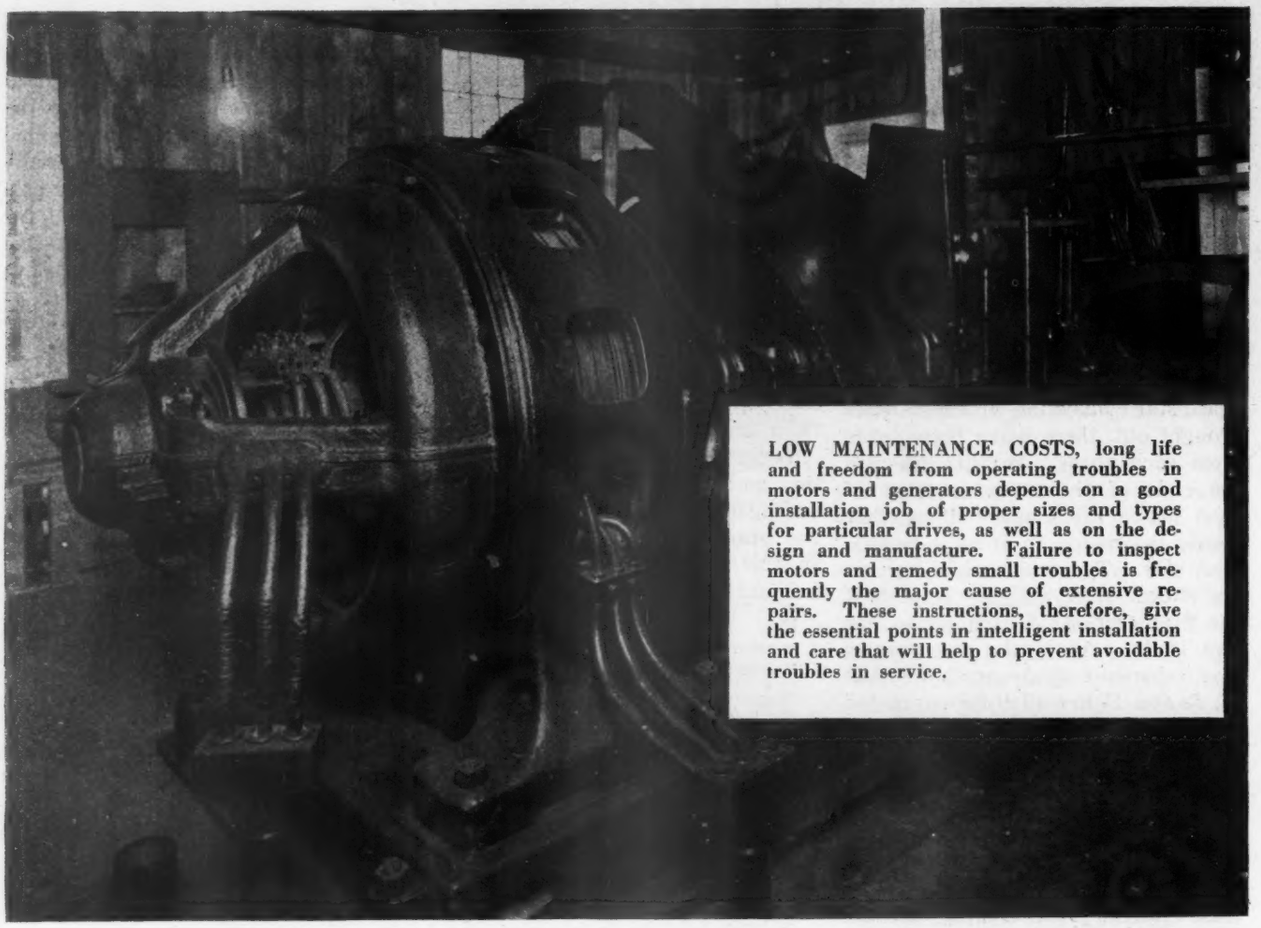
It will be noticed in all the special diagrams given here that the check used is the one that assumes the current flowing in on each lead, as this is the best one to use for line diagrams. This method is explained fully in the article on page 491 of the October, 1923, issue of INDUSTRIAL ENGINEER.

There are some three-phase induction motors that have the windings arranged so they can be used for the star-delta method of starting. In this method the winding is designed to operate at the line voltage with a series-delta connection. Then if a series-star connection is used to start the motor, it will have the same effect as reducing the applied line voltage to 58 per cent. Drawing *P* of Fig. 7 shows a four-pole winding which can be arranged for series-star or series-delta. In this case the phases are not divided, but the beginning and ending lead of each phase is brought out so that a star or a delta connection can be made outside the motor, as shown at *A* and *B*.

In case the tags become lost from the leads of double-voltage motors, the leads must be identified before the motor can be connected for operation. The following method of locating these leads requires a test lamp or buzzer and the removal of one end bell. The tests can be made in almost any location. In making the tests the various circuits are followed out and then marked with tags. Suppose the winding being tested is a four-pole, two-phase winding like that shown at *M* in Fig. 6. We know that such a winding is divided into four sections and that each section has two leads. Then the first step is to separate the leads into the pairs which are on the same sections. To do this hold one test lead on any one motor lead and test the other motor leads until one is *(Continued on page 562)*

Fig. 7—A series-parallel delta winding and a star-delta winding. The small diagrams *A*, *B* and *C* show how the different connections are made. The small circles, *D*, show how the leads may be brought out to avoid crossing of leads outside the motor. For the three-phase, four-pole delta winding at *O* the series connection is obtained, as shown at *A*, by making the following connections: lines to L_1, L_2 and L_3, respectively; L_4 to L_7; L_5 to L_8; L_6 to L_9. The two-parallel arrangement, as shown at *B* and *C*, requires the following connections: one line to L_1, L_6, and L_7; the second line to L_2, L_4, and L_8; the third line to L_3, L_5, and L_9. For the three-phase, four-pole winding shown at *P* the star arrangement shown at *A* requires the following connections: lines to L_1, L_3, and L_5, respectively; L_2 to L_4 to L_6. The delta connection as shown at *B* requires that: one line connect to L_1 and L_6; the second line to L_2 and L_3; the third line to L_4 and L_5.





LOW MAINTENANCE COSTS, long life and freedom from operating troubles in motors and generators depends on a good installation job of proper sizes and types for particular drives, as well as on the design and manufacture. Failure to inspect motors and remedy small troubles is frequently the major cause of extensive repairs. These instructions, therefore, give the essential points in intelligent installation and care that will help to prevent avoidable troubles in service.

Recommendations of Electric Power Club for

Installation and Care of Motors and Generators

From the Standpoint of Those in Charge of Their Operation and Maintenance

UNDER date of September, 1923, the Electric Power Club has issued instructions for the installation, operation and care of electric motors and generators. These instructions are similar in scope to the instructions for the care and operation of power transformers, published in the July, 1923, number of INDUSTRIAL ENGINEER and also issued by the Electric Power Club in pamphlet form. The Electric Power Club is an organization whose members are firms engaged in the manufacture of electrical power apparatus and control equipment. The purpose of the organization is to devise standards of practice and construction in application and design of electrical equipment, to discuss subjects of interest to the industry in which its members are engaged and to promote advancements and improvements in the production and use of electrical equipment.

In the introduction to the instructions for the installation, operation and care of electric motors and generators, the following comment is made:

"The life and successful operation of electric motors and generators depend upon their proper installation and maintenance as well as upon their proper design and manufacture. While motors and generators require less care than almost any other type of power apparatus, neglect of certain fundamental requirements may lead to serious trouble if not to the loss of the equipment. A wide distribution of information of this character is, therefore, important and these brief instructions have been prepared for the assistance of those responsible for the installation, operation and maintenance of electric motors and generators."

These instructions are given in full below:

I—GENERAL

Shipment.—All motors and generators are shipped completely assembled ready to set on the foundations, except those sizes which are limited by transportation and handling facilities.

Storage.—When machines are received, they should be kept in a dry, clean place and especially when they are put in storage and are not installed immediately.

Machined parts are slushed or painted before shipment to prevent rust. If machines are to be stored for any length of time, those parts should be inspected periodically to see that rusting has not started and re-slushed if necessary.

A safe and reliable heating system should be provided to protect the windings of machines from alternate freezing and thawing. An electric heater with a thermostatic control is recommended when sufficient current is available.

Unpacking. — Unnecessary handling of machines at low temperature should be avoided as castings are more easily broken at very low temperature than at normal temperature.

When unpacking and handling machines the windings and other parts should be protected from damage.

Machines should be thoroughly inspected as soon as they are unpacked to see if they have been damaged in transit and to make sure that all parts, accessories, etc., are in the proper condition and position. All instructions and connection diagrams received from the manufacturer should be left with the machine.

If the windings of a machine have been exposed to low temperature, they should not be uncovered until they have had sufficient time to attain a temperature nearly as high as that of the room in which they are to be unpacked. If this procedure is not followed, the machine will sweat.

Handling.—Traveling cranes are exceedingly convenient in handling machines. Where stations or factories are not so equipped it is desirable, except for very small machines, for the user to build a crib or horse of heavy timbers for handling the machine. It will be found convenient and advantageous to retain the crib for further use.

Whenever practicable, a complete machine should be moved as a unit. This eliminates many possible troubles with windings, armature, slip rings, etc. Where machines are provided with eye bolts, these should be used for lifting in preference to slings. When lifting motor-generator sets, care should be taken not to spring the shaft by attaching the hooks or slings improperly.

Armatures.—When necessary to move the armature or rotor alone, the only safe method of supporting it while either moving or stationary is by slings or blocking under the shaft or by a padded cradle under the core laminations. The bearing journals must be protected so as not to mar the polished surface. The weight of the armature and field frame should not be allowed to rest on the base until the base has been leveled and grouted and the grout has had time to set hard.

The whole armature surface may be considered as subject to damage either to the bands, wedges, clips or insulation unless properly handled. Every precaution should be taken to avoid damaging any of the windings or other parts.

Commutator segments are very easily displaced and, therefore, an armature should never be lifted by passing a sling around the commutator. A spreader should always be used when lifting an armature to prevent the slings from drawing over armature band clips, collector rings, or commutator. Slings placed on the magnet frame must be so drawn as to avoid chafing the field coil insulation and the connections between coils. A rotor should never be lifted or supported by the slip rings.

If a wire rope is used for a sling, some waste or rags should be inserted between the sling and the machine to prevent marring the paint. In handling a complete machine, special care should be exercised to protect the oil gauges from damage.

Bearing Power of Soils

Soil	Tons Per Sq. Ft.	Authority
Good solid natural earth	4	N. Y. Building Laws
Pure clay, 15 ft. thick, no admixtures of foreign substances except gravel	1.75	Chicago Bldg. Ordinance
Dry sand, 15 ft. thick, no admixtures of foreign substances	2	Chicago Bldg. Ordinance
Clay and sand mixed	1.5	Chicago Bldg. Ordinance
Hard rock on native bed	2.5	Richey
Ledge rock	36	Richey
Hard pan	8	Richey
Gravel	5	Richey
Clean clay	4	Richey
Dry clay	3	Richey
Wet sand	2	Richey
Loam	1	Richey

Drying Out.—All electrical machinery not especially constructed to resist injury by moisture should be kept dry. If a machine has been exposed to moisture, the windings should be thoroughly dried before the machine is placed in service. Small machines can be baked in ovens and larger units can be dried by passing current through the windings. In either case, however, the temperature should be kept within a maximum of 85 degrees C. The temperature should be raised gradually and should be kept as nearly uniform as possible throughout the windings.

II—Installation

Location.—In order to permit satisfactory operation, the location of machines should be arranged to meet the following conditions:

1—Protection from moisture, escaping steam, dripping pipes, oil, acid, alkali, chlorine or other gases.
2—Protection from dust, dirt, lint or any other injurious substances.
3—Good ventilation and accessibility for cleaning and inspection with respect to the surrounding equipment. Motors should not be exposed to excessively high surrounding air temperatures, that is, where the ultimate temperature of the windings will be over 90 degrees C.
4—Sufficient floor space for a belted exciter if used.

**Foundation.*—Contracts for the purchase of electric motors and generators usually make the purchaser responsible for furnishing such foundations as may be required, and, in the absence of contract provisions, the following general information may be of value.

Foundations are generally made of concrete. The usual concrete mixture consists of one part cement, three parts clean, sharp sand and six parts crushed stone or gravel. This is sometimes expressed as 1:3:6. However, for quick work where quick setting is required, a 1:2:4 mixture can be used. Brick or stone can be set in a mortar consisting of one part cement and three parts sand. These foundations should be allowed to set at least two or three weeks before the machine is placed on them.

The size of a foundation is determined by the size of the machine and by the stress imposed by the machine. Any foundation must have sufficient area at its base to support its own weight and the weight of the machines. Some experience is necessary to design as light a foundation as will do, so it is better practice to make foundations with a generous factor of safety. Clean, sharp sand is considered to be a good bearing soil and the bearing power of different soils is given in the accompanying table.

No general rule can be given for the proper weight of a foundation,

*This information is particularly applicable to large machines. For small machines, wood or iron framework is usually used but unless substantial ironwork or heavy seasoned timbers are used, the machines are liable to get out of alignment and vibrate.

but usually if the foundation is large enough to include all of the foundation bolts of the machine and extends to a good bottom, it will be sufficiently heavy for the purpose.

In most applications of large machines, the hollowed-out type of foundation is required. The position of the holding-down bolts is shown on the outline drawings of the machine and a template should be used for laying out the location of all the foundation bolts. In order to permit a slight variation in the position of these bolts, they should be located in iron pipes with an inside diameter at least 1 in. larger and preferably 2 in. larger than the diameter of the bolts. (See Fig. 1.) When the machine is in its exact location, the iron pipes should be filled with concrete or grout to the top of the foundation.

Bolts can also be cast in solid and foundation washers can be used on the lower ends of the bolts to secure them in the foundation. Ordinary round building washers, pieces of steel plate with holes punched through their centers, pieces of angle iron, etc., are sometimes used but standard foundation washers are better, as they are designed to prevent the nut from turning on the bolt. With large machines, it is desirable to have pockets in the concrete large enough to take the plates. The foundation bolts and plates can be hung in the holes and the holes filled when grouting the base. This insures a good bond between the foundation and the grout, in and under the base, and the proper setting of the foundation bolts.

Good grout is a mixture consisting of one-half clean, sharp sand and one-half cement. It should be made thin enough to flow readily. Before pouring the grout all dust and dirt should be cleaned off and the foundation wet down thoroughly. It is advisable to use a slow setting cement with large castings, otherwise the temperature rise of the setting grout may cause distortion of the casting. Old cement sets slower than new.

Where assembled machines are mounted on bases, the base should be carefully leveled before being grouted in. An average distance of 1 inch should be allowed between the top of the foundation and the bottom of the base for grouting. If this distance is too large, there is a chance of the grouting shrinking away from the base.

To grout the base, build a low dam around the inside and outside and float in the grout mixture to a height of one-quarter inch above the lower face of the base. If the grouting is too deep, it will make it difficult to subsequently remove the base if desired.

Bases of machines shipped disassembled should be also grouted in but the grout must be given sufficient time to "set hard" before the stators and pillow blocks are put in place. This work should be done under the supervision of an expert on the lining up of machinery.

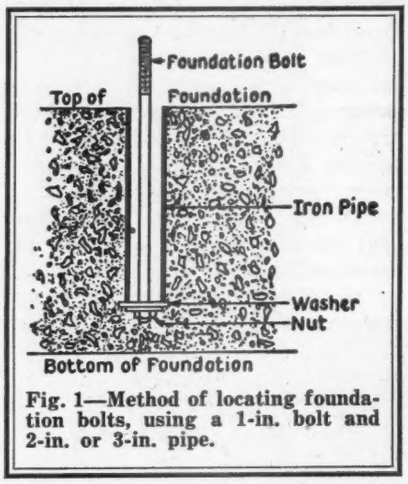


Fig. 1—Method of locating foundation bolts, using a 1-in. bolt and 2-in. or 3-in. pipe.

Motor and generator bases are not supposed to carry any weight when unevenly supported. To prevent distortion, therefore, they should be carefully leveled by means of leveling wedges and grouted before any weight is placed on them.

Erection.—Machines must be lined up on their foundations, so that the driving and driven shafts are parallel. Driving and driven pulleys must be in line so that the belt will run true. Driving pinions and their gears must mesh accurately. If the machines are direct connected the shafts must be in line. Full assurance that the pulleys are properly aligned can be obtained by temporarily installing the belt and turning the pulleys by hand where this is possible. After the machines have been accurately aligned, the slide rails, bed plate, or the machine itself (as the case may be) must be bolted rigidly to the foundations.

Wall and Ceiling Mounting.—Motors or generators intended for floor, wall or ceiling mounting have end shields or bearing housings which can be turned through 90 or 180 degrees. Machines are shipped for floor mounting unless otherwise specified. For wall or ceiling mounting, the end shields or bearing housing must first be turned through the corresponding angle and the connections rearranged as per diagram or instructions furnished by the manufacturer. Some machines with brushes may require special brush holders when mounted on the wall. It is preferable that adjustments for ceiling or side wall suspension be made before the machine is shipped and the manufacturer should be advised accordingly when the machine is ordered.

Whenever the end shields are removed, care must be exercised to see that the surfaces of the joints are perfectly clean before the end shields are replaced and the bolts tightened, otherwise the alignment may be so affected that the bearings will heat unduly. The air gap should also be checked to see that it is uniform all around after the end shields have been bolted into place.

III—Method of Drive

Bearings.—Before a machine is started the bearing housings should be inspected to see that there is no dirt or foreign matter in the reservoirs and that the oil rings are free. If the reservoir is not clean, it should be rinsed out with kerosene. The reservoirs should be filled to within one-sixteenth inch of overflowing with a petroleum oil before the motor is started.

Connections and Drives.—The connection of leads to machine terminals should not be of a permanent nature until the direction of rotation or polarity has been determined. When a controller or starter is required it should be connected in accordance with the diagram or instructions furnished with it.

All permanent connections should be made mechanically and electrically secure and the terminal wires must be securely soldered into the connectors supplied with the machines.

All wiring should be carefully installed in accordance with the National Electrical Code and any local requirements, and should be of ample capacity so that the voltage drop will not exceed 2 per cent at full load current.

Safety Regulations.—All belts, chains, gears, couplings and machines should be properly housed or suitably guarded in accordance with the National, State or Local Safety Regulations in effect.

Belt Drive.—The pulleys of the driving and driven machines must be accurately aligned and the belt tension so adjusted that the belt is

just tight enough to carry the load without slipping. The smooth side of the belt should be next to the pulley. Wherever possible, the lower side of the belt should be the driving side, that is, the tight side of the belt should be at the bottom and the slack side on the top.

Horizontal belt drives are best and vertical belt drives should be avoided. The distance between pulley centers with open belting should never be less than 2½ times the diameter of the larger pulley. Pulleys should be placed as close as possible to a bearing. Double-ply belts should not be used on pulleys less than 9 inches in diameter. The use of endless belts is recommended. Where it is necessary to have short belt centers or vertical belts, a belt-tightener should be used. When a motor belt requires frequent adjusting, it is advisable to have the adjusting screw of the sliding base on the side of the motor nearest the belt. Excessive belt tension can be avoided by using belts of the proper width. The following statement will afford a rough check:

1-in. width will transmit with single leather belting 1 hp., and with double leather belting 1.4 hp. for each 1,000 feet per minute belt speed up to a maximum of 5,000 feet per minute.

The following limitations represent good practice in belting motors under normal conditions to relatively high speed drives:

The use of 1,800 or 1,700 r.p.m. belted motors should be limited to a maximum of 40 hp.

The use of 1,500 or 1,440 r.p.m. belted motors should be limited to a maximum of 50 hp.

The use of 1,200 or 1,150 r.p.m. belted motors should be limited to a maximum of 75 hp.

The use of 900 or 850 r.p.m. belted motors should be limited to a maximum of 125 hp.

Gear Connection. — Geared machines must be accurately aligned and rigidly fastened to a common base. An error of a few mils may produce serious vibrations and ultimately break the shaft or wreck the apparatus. When gears are properly meshed, it should be possible to pull a thin piece of paper from between the teeth without its tearing.

The following limitations represent good practice in gearing motors, based on the use of steel pinions:

The use of 1,800 or 1,700 r.p.m. geared motors should be limited to a maximum of 5 hp.

The use of 1,500 or 1,440 r.p.m. geared motors should be limited to a maximum of 10 hp.

The use of 1,200 or 1,150 r.p.m. geared motors should be limited to a maximum of 25 hp.

The use of 900 or 850 r.p.m. geared motors should be limited to a maximum of 50 hp.

The use of 750 or 720 r.p.m. geared motors should be limited to a maximum of 75 hp.

The use of outboard bearings should be specified for general purpose motors with geared drive in frame sizes of 75 hp., 850 to 900 r.p.m., and larger.

Direct Connection.—Direct connected machines must be mounted on and rigidly fastened to a common base and it is essential that the machines be accurately aligned. It is even essential that the two shafts be in line where so-called flexible couplings are used, otherwise trouble from end thrust may be encountered.

Couplings are usually so made that a straight edge can be placed against the outer diameter to determine whether the coupling faces are in line. This check on the alignment should be made on top, bottom and sides, and with rotating parts moved to different positions.

Chain Drive.—Machines must be accurately aligned for chain drive and so mounted that the chain may be tightened. Wherever possible, vertical chain drives should be avoided and the machines should be so mounted that the chain may be conveniently taken off and replaced without an undue loss of time.

IV—Operation Covering Initial Starting and Stopping.

The precautions which should be observed by the operator are given in the accompanying table.

Practical Points in Operation of Motors and Generators

That Will Prevent Injury Through Ignorance or Carelessness When Equipment Is First Started And Stopped and After It Is Placed in Service

1. *In General, Make Sure:*
(a) That all bolts, nuts, screws, and oil drain plugs are tight.
(b) That the oil wells are filled with a good grade of mineral oil.
(c) That the commutator, slip rings and other parts are clean.
(d) That after all possible external load has been removed, the armature or rotor can be turned over by hand and runs freely.
(e) That all external wiring connections check with the manufacturer's diagrams.
(f) That the brushes move freely in the holders and make firm, even contact with the commutator or collector rings.
(g) That wherever possible both motors and generators are operated initially without load (except series motors, which should never be operated with less than 50 per cent full load), for a period of several hours.

2. *When Starting Motors, Make Sure:*
(a) That the line voltage (and frequency on A. C. motors) corresponds with the voltage on the nameplate.
(b) That the controller is in the "off" position.
(c) That the circuit breaker (where used) or the line switch is closed first.
(d) That the controller handle is then slowly but firmly moved on to each point of contact until it is in the running position (about 20 seconds should be consumed in this operation).
(e) That if a compensator is used, its switch lever is moved to the starting position and when the motor comes up to speed (in about 5 to 20 seconds) the lever is quickly thrown into the running position.

3. *When Starting Generators, Make Sure:*
(a) That all resistance in the field rheostat is placed in the field circuit.
(b) That all switches connecting the generator to any load are open.
(c) That the prime mover is slowly started and brought up to speed.
(d) That the resistance is gradually cut out of the field circuit until normal rated voltage is secured.
(e) That the load is then gradually applied.

4. *When Stopping Motors, Make Sure:*
(a) That the circuit breaker or starting compensator is tripped or the line switch opened.
(b) That the controller handle has returned to the "off" position by the time the motor has stopped.

5. *When Stopping Generators, Make Sure:*
(a) That the load is reduced by adjusting the field rheostat to increase the resistance in the generator field and that when the load is comparatively small, all the field resistance is inserted in series with the field windings.
(b) That the circuit breaker or line switch is opened.
(c) That the prime mover is shut down.
(d) That the field switch is opened on separately excited machines.

Parallel Running of A. C. Generators.—A. C. generators which are to operate in parallel must be run at speeds which will give equal frequencies. The successful operation of generators connected to different prime movers is dependent in a great measure upon the governing of the prime movers and upon the relative flywheel effects of the different machines.

Synchronizing.—Before two alternators are synchronized for the first time, they should be tested for phase rotation. This can be accomplished by connecting each separately to an induction motor to see if the same rotation is obtained. Another method is to throw the machines together on very low voltage with ammeters in circuit. Wide fluctuation of current on the ammeters will indicate wrong phase relation. The phase rotation can be reversed by interchanging two leads of a three-phase machine or reversing the two leads of one phase of a two-phase machine.

The usual method of synchronizing is by the use of a synchroscope. A common method, however, is to connect a lamp or lamps of proper voltage in series with the low tension windings of two transformers, the high tension windings of which are connected, one across the line and the other across the incoming machine. If the secondaries are opposed, that is, connected as for ordinary multiple connection, the main switch of the incoming machine should be closed when the lamps are dark. If the secondary or the primary leads of one of the transformers be reversed, then the main switch of the incoming machine should be thrown in when the lamps are bright. It is preferable to connect for synchronizing when the lamps are dark. The main switch should not be closed until the fluctuations in the light of the lamps become slow, that is, about one in two or three seconds.

Stopping Generators in Parallel.—The prime mover should be throttled and the field current reduced until the ammeter and wattmeter indicate a very light load. The oil circuit breaker should then be tripped, the prime mover stopped and the field switch opened.

V—Care and Maintenance

Inspection.—A systematic inspection at least once a week is necessary to insure the best operation of motors and generators and the following points should be given special attention and consideration.

Cleanliness.—Both the interior and exterior of machines should be kept free from water, oil, dirt, or grease. For machines installed in very dirty places, troubles may be averted by periodically removing the rotor or armature and thoroughly cleaning the machine. A vacuum cleaner is highly recommended for cleaning assembled machines. The use of compressed air is not recommended on assembled A. C. motors. It is especially objectionable on machines installed in foundries, machine shops, or locations where there is much carbon dust, metallic chips, etc., as the compressed air may drive the dirt or metallic chips into the windings, and cause breakdowns. On direct-current machines the use of compressed air is not objectionable because all the parts are more or less accessible, especially the commutator and brushes.

Lubrication of Bearings.—The life of bearings is affected by the lubrication, belt tension and alignment of the driving and driven shafts. Excessive wear and heating of all bearings can be reduced to a minimum by adequate lubrication, proper belt tension and accurate alignment. When bearings are unduly worn, they should be replaced, and after the new bearings have been put in, the air gap should be tested to see that it is uniform all around.

Oil wells should be filled with petroleum oil (not vegetable or animal oil) through the oil fillers while the machine is at standstill up to one-sixteenth inch of the top of the oil filler. Experience has shown that animal or vegetable oils or greases, or admixtures of them with mineral or petroleum oil will dry and gum, and by gumming ducts and oil rings, prevent the free flow of oil to the bearings. Incorrect oil level may be experienced if the oil wells are filled while the motor is running. After a motor has operated for the first week, the oil should be drawn off and the bearings washed out with kerosene, to wash out all sediment before refilling the bearings with oil. The drainage plugs should be taken out and dipped in a mixture of red lead and shellac and then replaced and tightened securely to prevent leakage. The bearings should be refilled at regular intervals, the frequency depending upon local conditions, such as cleanliness, severity or continuity of service, etc. After changing the oil, the oil rings should be inspected to see that they are in proper position and turn freely.

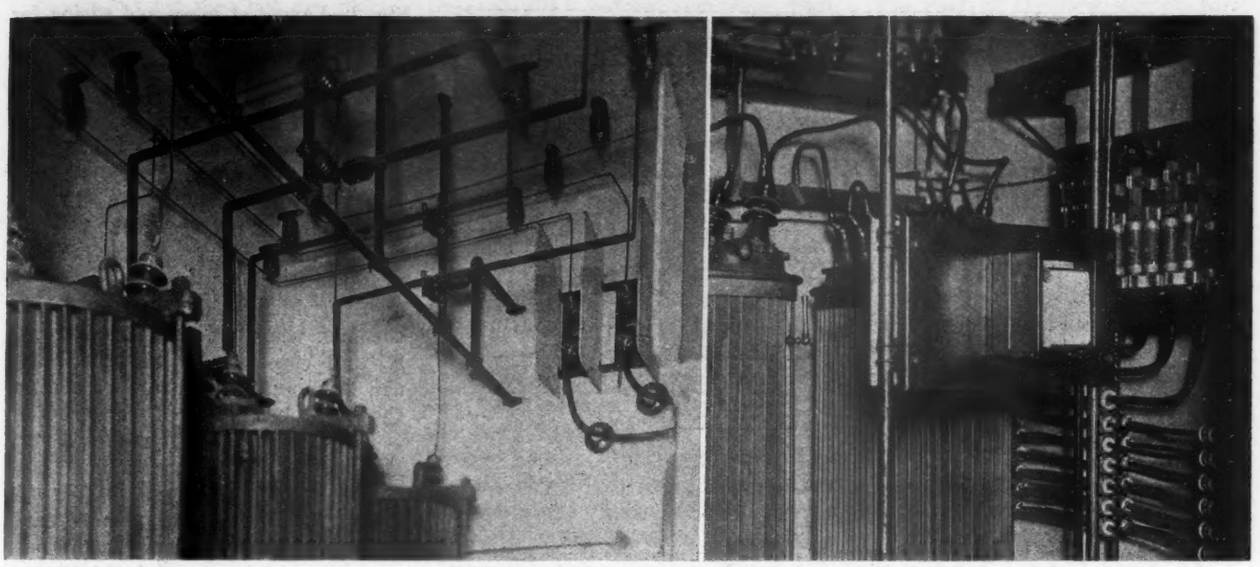
Brush Tension.—The brushes should be inspected to see that they move freely in the holders and at the same time make firm, even contact with the commutator. The brush tension should be checked regularly to make sure that the proper tension (1¾ lbs. to 3 lbs. per sq. in.) is maintained by the spring.

Fitting.—When replacing brushes they should be fitted by means of fine sandpaper folded around the commutator and the rotor revolved by hand in the desired direction until a proper fit is obtained. On some machines, the sandpaper can be held in place if it is cut to a width slightly narrower than the commutator, and the front end of the strip inserted into one of the narrow slots between commutator bars (where the mica has been undercut), and then folded back around the commutator by slowly revolving the armature by hand until the paper moves under a set of brushes.

Position.—An operator should never shift the position of the brushes unless he knows positively that the brush position is incorrect or it is desired to change the direction of rotation or mounting of the machine. On machines with commutating poles, the position of the brushes is fixed on the neutral point at the factory and the position of the brushes on such machines should never be shifted except to make change as indicated in the previous sentence or for compounding or parallel operation of generators.

Brush Pigtails.—Care should be taken to see that the pigtails or flexible copper conductors are firmly fastened in place so that they will carry their full current from the brush to the brush holder. A slight extra length should be left in the pigtails because if they are too tight they might tend to pull the brush out of line and out of proper contact with the surface of the commutator.

Commutator.—Commutators should be always kept clean and well polished. Under normal operating conditions, a commutator will require only occasional cleaning with a piece of canvas or non-linting material. No vaseline or oil of any description should be used on a commutator. In case the commutator has become rough, this roughness may be removed by polishing the commutator with a piece of sandstone, which is formed to the same radius *(Continued on page 563)*



The photograph at the left shows three 333-kva. transformers with bare copper buses for 15,000 volts on post-type insulators. The low-tension buses of rectangular copper are likewise supported on post-type insulators some of which are on the ceiling while others are fastened to a pipework frame. The photograph at the right shows how the low-tension feeders are carried by spool-type insulators which are clamped to pipes. The distribution switchboard is shown at the extreme right and the 450-kva. transformer bank is in the rear.

Details on the

Remodeling of An Industrial Substation

To Receive Purchased Energy at 13,200 Volts Together With Some Installation Features That Held the Cost Down.

By EUSTACE C. SOARES

Electrical Engineer, Orphuls & Hill, Inc., New York, N. Y.

IN THIS article layout and installation details are given for the remodeling of a 1,450-kva. substation at the plant of the Anheuser-Busch Ice & Cold Storage Company in New York City to receive energy from the New York Edison system at 13,200 volts and provide a safe installation at a reasonable cost.

The substation originally had three 150-kva. transformers operating at 7,800/440-220 volts. There have been added three 333-kva. transformers and the building was enlarged to house this additional equipment. These transformers are operating at 7,800/440-220 volts, but they may also be connected for 13,200 volts on the high-tension side. The high-tension equipment is designed for 15,000 volts. The entire job consisted in enlarging the building, installing the new 1,000-kva. bank of transformers with switches and buses, and making connections from this and the old bank to the new distribution switchboard, connecting the plant feeders to this board, and other minor alterations. A bill of materials covering this construction, but omitting the materials required for the building itself, is listed in the accompanying table. The cost of the material during the winter of 1921-22 was $7,319. Enlarging the building, blocking up an old door and cutting a new one cost approximately $1,675. The construction work was done by the plant operating department under the direction of the consulting engineer. If a contractor had done the work the charges would have probably been higher to allow a profit.

WHEN IT BECAME necessary to make changes in a step-down transformer substation at an industrial plant in New York City, to receive energy purchased from a central station system at 13,200 volts, some construction details of transformer house, buses and wiring layout were worked out that held the completed cost of the 1,450-kva. substation, including building changes, to $6.20 per kva. The bill of material and installation details given in this article show how this job was handled.

The center part of the substation building is reserved for the New York Edison Company's incoming 7,800-volt line switches, meters, etc. From this point high-voltage cables run towards both transformer banks which are located at the ends of the building. This is No. 0, 15,000-volt, single-conductor, varnished-cambric-covered cable and it is supported by 15,000-volt, pin-type insulators. This cable connects to three single-pole disconnect switches at each transformer. From these switches the new construction is of ⅜-in. bare round copper rod. As seen in the photograph on this page, the bare rod bus is carried over the transformers near the ceiling on 15,000-volt cement post insulating supports.

The low-tension bus is similarly mounted on the ceiling and consists of 3-in. x ½-in. copper bars. The photograph shows clearly the overhead bus construction which gives

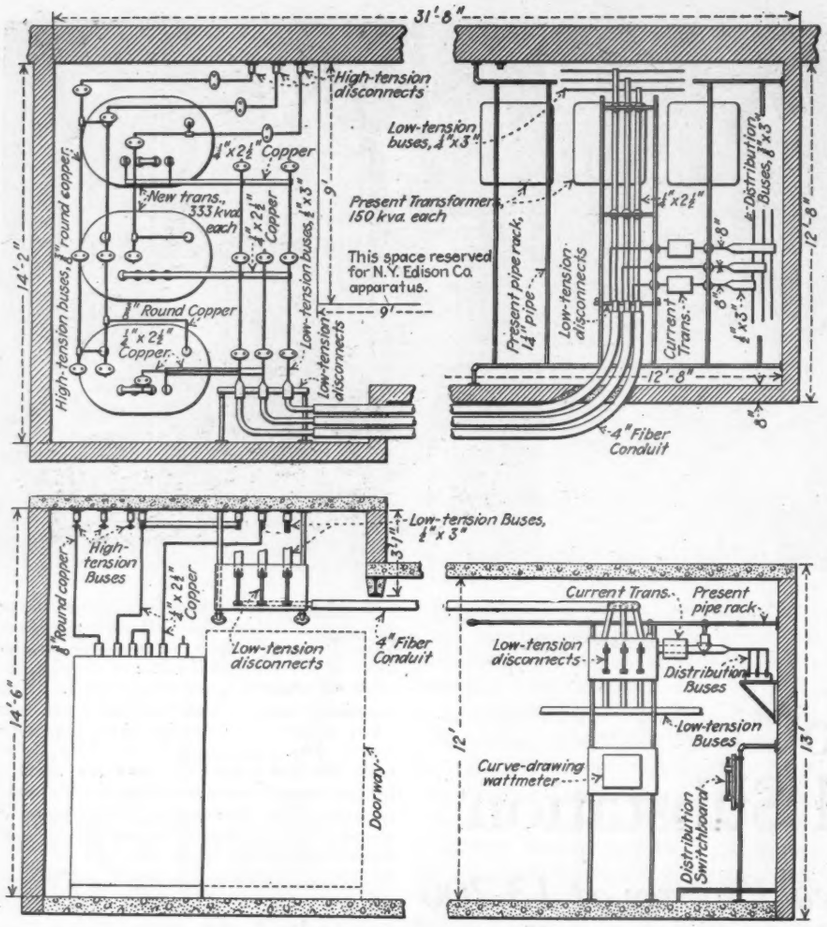


Fig. 2—Layout of buses and wiring for the 1,500-kva. substation shown in the photographs at the start of this article.

a very neat arrangement. Additional supports for some of the leads from the buses to the transformer terminals were mounted on a pipe framework, as may be seen.

Where an industrial substation is provided with a proper room of its own to which no one has access but the men whose duty it is to operate it, and especially where the buses can be mounted up near the ceiling, the bare bus type of construction is to be preferred. It makes a very neat job at a reasonable cost, and there is no question as regards safety. Men are always more careful around bare copper than where the wire is insulated. Of course, this statement regarding safety does not apply where the transformer bank is so small that the terminals can be readily reached from the floor. In such a case it is probably preferable to use insulated wire. It has been general practice to use insulated wire for the high-tension bus in industrial substations but this has been due mainly to convention rather than for any other reason.

Bill of Material for a 1,450-kva. Substation

THIS LIST of electrical materials is for a 1,450-kva. substation operating at 7,800/440-220 volts and designed for 13,200-volt operation in the future. All the high-tension equipment is rated at 15,000 volts. The station has two banks of transformers, one old 450-kva. bank and a new 1,000-kva. bank. All of the equipment* used is included in this list except the old transformers and their buses and leads.

3 Transformers, O.I.S.C. 333 kva. each, 13,200-7,800/440-220 volts.

6 Disconnecting switches, 100-amp. 15,000 volts.

1 Slate panel (2-in.) with three 1,500 amp. disconnecting switches for low-tension side of 1,000-kva. bank.

1 Slate panel (1½-in.) with three 600-amp. disconnecting switches for low tension side of 450-kva. bank, complete with pipe support and slate panel for meter.

1 Distribution switchboard complete with fuses and pipe support. (See text.)

24 Insulators, pin-type, 15,000 volt.

17 Cement post insulating supports, 15,000-volt, for ⅜-in. round bus.

12 Single-pipe-mounting clamp insulator supports; 6 with 1½-in. spools and 6 with 1-in. spools.

48 Double-pipe-mounting clamp insulator supports; 18 with 1⅛-in. spools and 30 with 1-in. spools.

Porcelain spools: 5 sets 1-in., 1 set 1½-in.

1 Curve-drawing wattmeter.

2 Current transformers, slip-over type, 1,200 to 5 amp.

100 ft. Cable, No. 0, 15,000-volt, single-conductor, varnished-cambric-covered.

50 ft. Ground wire, No. 2.

250 ft. Wire, rubber-covered, double-braid, No. 14.

Bare copper, round, 10 lengths, 10-ft. long, ⅜-in.

Rectangular hard-drawn copper: 8 pieces, 12-ft. long, 2½-in. x ¼-in.; 1 piece, 10 ft. long, 2½-in. x ¼-in.; 4 pieces, 12-ft. long, 3-in. x ½-in.; 2 pieces, 10-ft. long, 3-in. x ½-in.; 3 pieces, 8-ft. 10-in. long, 3-in. x ⅛-in.; 60 ft., 1½-in. x 1¼-in.; 10-ft., ⅝-in. x ⅛-in.

9 Fiber conduit, drive-joint, 5-ft. lengths, 4-in. diam.

3 Fiber conduit elbows, 90-deg., 36-in. radius.

20 ft. conduit, 1-in. and 70 ft. ½-in.

Conduit fittings: (3) brackets for supporting fiber conduit; (2) 1-in. E condulets; (1) 1-in. L.L. condulet; (1) 6-hole Porcelain cover for 1-in. condulet; (2) 3-hole covers; (5) ½-in. L.L. condulets; (5) ½-in. couplings; (6) junction boxes; (10) ½-in. bushings; (20) ½-in. locknuts; (3) base receptacles for attachment plugs.

150 ft. Pipe, 1¼-in.

Pipe fittings: 28 oval floor flanges; 14 clamp tees; (15) 90-deg. elbows; 1 side outlet elbow; 12 single U-bolt panel supports.

1 Exhaust fan, 18-in.

1 Wooden platform in front of distribution switchboard.

1 Rubber mat for platform.

1 Cut-out, 3-wire, 6-amp.

1 Snap switch, 20-amp.

3 Bracket lights with keyless sockets.

1 Switch hook, 6-ft.

Miscellaneous parts: Copper plated bolts, nuts and washers; cable lugs; screw connectors; bolts; nuts; lag screws; lead shields; bus-bar clamps, etc.

Miscellaneous materials: 12-lb., ¾-in. friction tape; 12-lb., ¾-in. rubber tape; 15-lb., ¾-in. varnished cambric tape; 1 gal. black insulating varnish; 6 balls twine; 35-lb. solder; 8-oz. soldering paste; 60-lb. kalsomine.

**The transformers were furnished by the Packard Electric Company; the high-tension equipment by the Electrical Engineers Equipment Company; the curve-drawing wattmeter by The Esterline-Angus Company.*

Disconnecting switches are placed on the low-tension side of each set of transformers. From the disconnecting switches of the 1,000-kva. bank to the low-tension bus there is a run of about 20 ft. As room was scarce inside the transformer house, this run was made outside the wall in 4-in. fiber conduit. Four 500,000 circ. mil cables per leg were employed. The use of fiber conduit gave an opportunity to use old cable for this run and thereby save money. There was a considerable amount of old cable which had been removed from engine-driven generators when they were replaced by the new transformer bank. The insulation on this cable was in poor condition but when it was installed in the fiber conduit good insulation on the cable was not necessary. This circuit and the disconnecting switch of the old bank of transformers connect to a short bus running to the distribution bus. Current transformers for a curve-drawing wattmeter are placed on this small bus. The meter panel as shown in the photograph on page 545 is mounted on the frame which supports the low-tension disconnecting switches of the 450-kva. bank.

The distribution bus is mounted over the distribution switchboard. It is of 3-in. x ⅜-in. copper bars. Connection is made to the switches on the board by about 2-ft. runs of copper bars. For the two 800-amp. switches 1½-in. x ½-in. bars are used; for the two 400-amp. switches, 1½-in. x ¼-in. bars; for the one 60-amp. switch, ⅝-in. x ⅛-in. bars. Each switch is three-pole single-throw. From the fuses below these switches the feeders are of rubber-covered wire which is supported by clamp-type insulators attached to iron pipes.

The transformer room is located in a large covered areaway where trucks drive in for loading and unloading. The accompanying drawing shows the general dimensions of the building. It was necessary to remove one wall of the old transformer room when putting on the extension. To provide for the maximum of safety to the workmen, a full wooden partition was built up just behind the wall in the old room and left up until the entire new room was completed. When the wall of the old transformer house was removed an I-beam was strung across to support the roof of the present house and the northern wall of the new house. Proper precautions were taken to support the old roof before removing the wall. The walls of the new house are of brick and are 8 in. thick. An opening was cut for a double door 7 ft. 6 in. by 8 ft. with a steel girder installed to support the wall above the new door opening. A 6-ft. by 10-ft. self-closing fireproof door was also located in the eastern wall.

The floor of the new transformer house is of stone concrete (1:3:5 mixture) with a finishing coat of cement mortar, ½ in. thick. The new floor was made flush with the floor in the old transformer house and is so pitched as to drain into the floor drain of the old transformer house. For supporting the transformers three rectangular stone-concrete pads (1:2:4 mixture) 41 in. wide, 61 in. long and 12 in. high, were placed in the position shown in the drawing.

The roof of the new section consists of a stone-concrete slab (1:2:4 mixture) sufficiently strong to carry a live load of 60-lb. per sq. ft. The western edge of the roof projects 4 in. into a 16-in. wall so as to be properly supported on that side. The roof was waterproofed, given a slight pitch, and provided with a 4-in. drain. This was necessary as ammonia condensers were located on the roof of the areaway and the possibility of trouble due to water falling on the roof of the transformer house had to be guarded against. The old transformer room was ventilated by means of louvres in the door and in the opening placed in the outside wall. An exhaust fan was placed in the outer wall of the new section and provides additional and more dependable ventilation.

Operating Temperatures for Electric Motors

By O. C. SCHOENFELD

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EXPERIENCE with the operation of electric motors leads to the conclusion that the anticipated troubles from excessive motor temperatures are due largely to a lack of knowledge, on the part of the men in charge, of the safe temperature at which motors can operate; also the operators usually lack a reliable means of determining the temperatures. These men are familiar with the guarantees of 40 deg. C. or 50 deg. C. rise given by the motor manufacturers, but this actually does not convey to them a condition that can be determined by their customary method of measuring temperature by feeling the external surfaces of the motors. There is, then, a need for informing the operators of the safe temperature limit and impressing upon them the necessity of accurately determining the temperature rise.

A thermometer placed on either the coils or the core of the motor is the proper way to measure temperature. The customary "feel" method of determining temperature in which a motor is considered hot when the hand cannot be held on the motor frame for any appreciable length of time, is very unreliable and always leads to the conclusion that the motor is hot when it is well under the maximum safe temperature. The degree of heat that the human hand can withstand without causing pain varies greatly with different persons; for example, the hand of a blacksmith will not be nearly so sensitive to heat as that of a clerk. The maximum temperature which the hand of the average person can stand for a short time is from 55 deg. C. to 65 deg. C., which means that when using the "feel" method a motor will be considered hot when it is from 25 deg. to 35 deg. under the maximum allowable temperature. In other words, the maximum safe temperature limit now used by many operators is from 25 deg. to 35 deg. below the real limit. This was brought out recently at a certain mill where one of our service men had been called to test a motor which the mill engineer and electrician thought was running excessively hot and about to burn out. Thermometer readings taken on the motor showed an actual temperature of only 53 deg. The motor felt hot, but had a thermometer been used and had the men been familiar with the safe temperature limit, all of the unnecessary anxiety would have been relieved without outside assistance.

In many factories various kinds of electrical meters for checking the operation of the motors are found but rarely does this equipment include thermometers. Much can be done to relieve the anxiety over motors which feel hot by familiarizing maintenance men with the maximum safe operating temperature of 90 deg. C. and encouraging its measurement with thermometers.

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, November, 1923

Don't Blame the Motor for Your Mistakes

A CORRESPONDENT recently told of a motor trouble which he had experienced that, when traced to its source, was found to be due to the use of a gear drive with too high motor speed. This is merely another bit of evidence in support of the fact that not all cases of motor trouble are primarily the fault of the motor itself. When trouble develops or abnormalities of operation are noticed with any piece of equipment, it will always pay to make a careful investigation to determine the real cause of the trouble. This is just as true of motor installations as it is of anything else.

The modern motor is as sturdy and reliable as human ingenuity and skill can make it. In its ruggedness and dependability it is second to few, if any, other pieces of equipment. Nevertheless, skill in the design and manufacture of motors can not entirely compensate for errors or carelessness in the selection, application or installation of motor drives.

For the purpose of giving motor users and operators the information which is necessary in order to avoid mistakes in these respects the Electric Power Club has recently issued a handbook of instructions covering the proper procedure in handling a motor from the time it is received in the plant until it is installed and put into service. Beginning on page 540 of this issue this handbook is reproduced in full and merits careful study on the part of anyone who has to install, operate or otherwise handle motor drives.

Equipment Will Not Compensate for Carelessness

WHEN THINGS go wrong many people grab the first patent cure-all that is handy and use it without stopping to consider what caused the trouble. In this they forget that the first step should be the removal of the cause, or the effect of the remedy will be only temporary. No man can continually eat too much and prevent stomach discomfort at the same time. Neither can he take a dose of medicine once a week, or every hour, when directions read "three times a day" and expect success.

Manufacturers of many kinds of equipment, particularly that designed to relieve the ills of operation—flexible couplings, clutches, silent chains, etc.—have been accused of making a patent medicine for the shop. Those who raise this cry the loudest point to a failure in their own shops. Investigations of these failures usually disclose that the new equipment was installed without removing the cause responsible for the former failure. For example, silent chains are installed without lining up the shaft; flexible couplings are put on and the alignment never checked up, or the couplings lubricated; belts too small for the load they are to carry, are used; self-aligning bearings are installed and the shafting never aligned.

Another common cause of failure which is similar to these, is to install equipment on a load much above the rating, to economize on first cost. The user then complains of the failure even though he took his medicine without reading or heeding the directions. Carelessness is often fatal when treating personal illness. Carelessness in following the rules prescribed by the manufacturer in the treatment of mechanical equipment may be just as serious. The metal or equipment that will take the place of common sense and carefulness has not yet been invented.

Talk Over Things That Are Not Wrong

CRITICISM and impatience on the part of the man who supervises others is sometimes a virtue and sometimes a fault. It all depends on the time and the place it is displayed. The man who is satisfied with everything and never offers suggestions for improvements is soon sized up as easy-going and the good-enough attitude gets into the thinking of his men. On the other hand the man who is never satisfied with anything and criticizes every job, however good it may be, is put down as a chronic grouch and a know-it-all, feared and disliked.

The first type is imposed upon and the second rarely ever develops initiative in his men, for they fear his criticism and follow instructions to the letter irrespective of the warnings of their better judgment. The superintendent or foreman who knows how to avoid a classification in these two extremes is the one who severely criticizes poor work and compliments good work with equal vigor and sincerity. A kind word and a helpful suggestion when things are going wrong in spite of the earnest endeavors of workmen, helps a lot, too.

But the best tonic of all for stimulating ambition and genuine interest in a hard-working gang, is a little talk by the boss on the things that have gone right and are going right because someone is using his head and applying his good judgment without being told every time. Just as nothing succeeds like success, initiative grows and thrives on results that bring a favorable comment from the boss. If you are not already doing it, call your men together once in a while and talk to them about the things that *have not gone wrong* and distribute the credit where it belongs. It pays.

Cost of Pumping Water

RECENT tests on steam-driven and electrically-driven pumping outfits in a steel mill have produced data that show marked savings possible with centrifugal pumps. In this particular case 30,000,000 gal. of water were required per day. The operating cost for the electric outfit was found to be $71.40 per day and that of a turbine-driven outfit $86.40 per day, which shows a saving in favor of the electrically-driven centrifugal outfit of $5,475 during a year's operation of 365 days. This is about 14 per cent of the cost of the turbine-driven outfit and would pay for the less expensive electrically-driven outfit in less than three years.

The same tests showed that the operating costs of direct-acting steam pumps vary from 3½ to 15 times that of the motor-driven centrifugal unit. From the standpoint of maintenance and attendance costs there were also marked advantages for the electric unit. One factor often overlooked is that centrifugal pumps electrically driven do not require a licensed engineer and have no steam line losses when standing idle.

While it may not always be possible to use electrically-driven pumps exclusively, particularly where emergency outfits are necessary to guard against an interruption of water supply in case of failures of electric power or injury to motor, the cost of all steam pumping is now so uneconomical that replacement by some electric units is one way of reducing the cost of pumping water in a large industrial works that requires lots of it.

When Is Oil Not Simply Oil?

THERE was a time when oil was simply oil and bearing troubles were expected and provided for just as the replacement of grates in a boiler. But with the coming of the lubrication specialist times have changed and almost everything that causes bearing troubles is blamed on the lubricant used. Now we have oils and greases called by many funny names and to discuss their merits and uses requires a technical lingo that rivals the language of the young physician in diagnosing the measles.

To know when oil is oil and not grease something must be known about viscosity, low cohesion and high adhesion, specific gravity and flash point, the characteristics of high-grade parafin base crudes and chemically pure animal fats, straight mineral and compounded oils, shaft speeds and temperatures, bearing composition and pressures and a whole lot of other things that may or may not happen under certain prescribed conditions.

But if you are patient and have a good memory you can learn a lot from everyone you talk to about lubrication. It's a big problem in a large works where a wide variety of equipment is operated and a total lack of practical details of lubrication is certain to call for unexpected repairs and costly shutdowns. In making a study of your problems, however, it is important to determine the difference between competitive language aimed to sell oil and information that will reduce bearing troubles and repairs. When you have found something that works well it's a good plan to remember the saying of your first boss perhaps fifteen or twenty years ago, that oil is cheaper than machinery—use plenty of it!

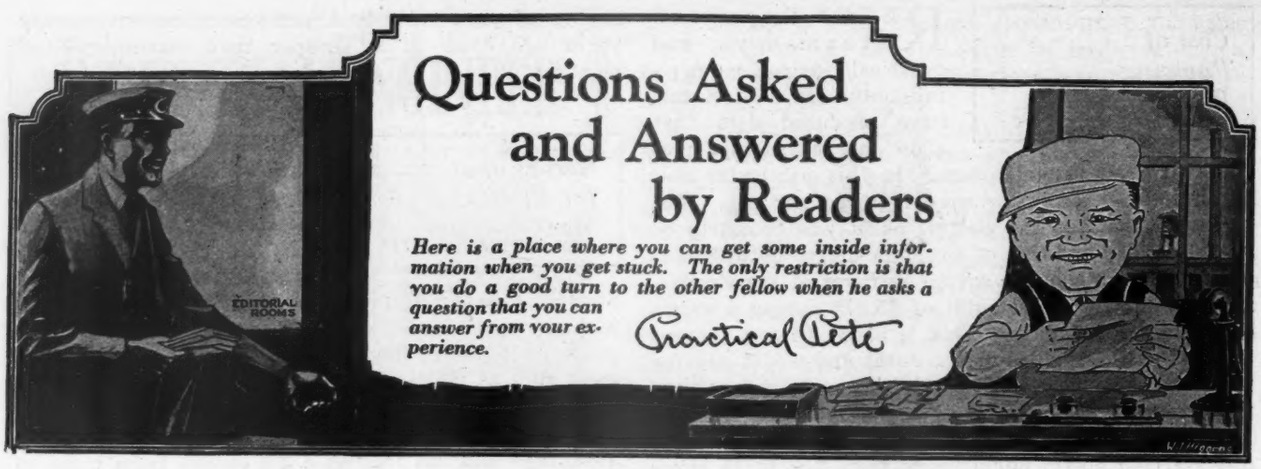
Recognition for Electrical Men

IN HIS paper "The Complete Electrification of the Foundry Industry" presented at the Buffalo (N. Y.) convention of the Association of Iron and Steel Electrical Engineers, Leonard W. Egan, engineer with the Ohio Steel Foundry Company of Lima, Ohio, pointed out that in foundries where power-driven equipment such as molding, sand-cutting and conveying machines and other devices has been introduced, the molder is allowed to apply his knowledge and skill to the best advantage and has increased his output from eight to ten times. In this connection he made a strong plea for a wider recognition of the results electrical men can secure in foundry work. He said:

> The advancement towards the complete electrification in foundries that now exists in the steel mills will not receive an impetus corresponding to that of the steel mill until foundry managements recognize the necessity of giving a higher standing to the electrical man. They must give him higher authority, allow a broader scope in his efforts and more consideration for his opinions and recommendations in the development of the industry. On the other hand, they should demand of him a broader knowledge of industrial-electrical applications and maintenance management in general. He must assume a more definite and stronger position in the application and the development of the equipment. He cannot longer be considered as a "trouble-shooter" and a "wire-fixer." He is a most vital factor in the production of service by each and by all units of the equipment. As the equipment is intended exclusively to produce and furnish service continuously and without interruption, without breakdowns if possible, and all of it at a minimum of maintenance cost, the degree of service that the equipment produces under operating conditions is intimately intermingled with his routine duties.

We agree most emphatically with Mr. Egan. But the ideas and responsibilities of electrical men in industrial work from a production standpoint are for the most part new. The extensive use of electrical service even in our large plants is a product of our present generation of workers, most of whom are still young. And those who have established for themselves jobs that carry recognition have had to fight their way to such recognition. It will not always be so. For management, even when most conservative, places responsibility on those who show results and on this basis electrical men in industrial work have a much brighter future than they may now realize. But nothing will be handed to them on a silver platter—it's results that count and of these there are plenty that are gradually but forcefully making a dent in the consciousness of industrial executives.

It is one of the functions of INDUSTRIAL ENGINEER to find the electrical men who are doing things and to interpret the results they are securing from a production standpoint in terms of profits in dollars and cents that the management can pass on to their stockholders as dividends. If you are one of these men remember the advice in the Good Book about hiding your light under a bushel. INDUSTRIAL ENGINEER provides the means for making a permanent record of what you have done along new lines and welcomes an opportunity to assist you in compiling the details.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Tire Heater for Wheels of Mining Locomotives—I should like to know where I can obtain a device for heating the tires for removal from the wheels of mining locomotives. The wheels are about 14 in. in diameter. I should prefer some device that, if possible, will not require the removal of wheels from under the locomotives in order to take off the tires and can use kerosene or gasoline as a fuel. If any reader of INDUSTRIAL ENGINEER has made an outfit which will do this work I shall appreciate it if he will give me full details.

Kildav, Ky. C. F. K.

* * * *

Trouble with Balance Coils on Lighting Circuit—I recently had trouble with a lighting circuit which was to be supplied by a 440-volt, 60-cycle generator. We wanted to get 110 volts, but the only apparatus available to make this change was two Westinghouse balance coils, built for reducing 220 volts to 110 volts. Numerous connections were tried, such as hooking up the two coils in series across one phase of the 440-volt lines, but the balance coils just would not balance the load. One circuit would receive about 150 volts, while the other would show only 85 volts.

Can anyone who has had wider experience than I in this line suggest a way to make these coils work together? Or can you tell me just why they will not work?

Smackover, Ark. W. N. T.

* * * *

Inexpensive Rectifier to Supply Direct Current from A. C. Circuit—I wish to obtain 110 volts direct current and as only 110 volts alternating current is available I should like to get complete details of an inexpensive electrolytic or other type of rectifier whereby I can step up the 110-volt alternating current to compensate for losses in rectifying and obtain 110 volts direct current. I wish to operate small fans and motors with the direct current. I shall appreciate it if someone can tell me how to make a suitable outfit.

Portland, Ore. V. G. W.

* * * *

Changing Small D. C. Motor to Operate on Alternating Current—I shall appreciate it very much if someone can tell me how I can rewind a small, 22-volt, direct-current, Hamilton-Beach vibrator motor to operate on 110 volts alternating current. The armature has 21 turns of No. 26 enameled wire and two coils per slot. The span is 1 to 6. The pitch of the leads is straight out. The two field coils are wound with 116 turns of No. 21 wire and the motor is connected in series.

Minneapolis, Minn. H. E. S.

* * * *

Electro-Magnet for Use on Alternating Current—Will someone please give us the information needed to make an electro-magnet, for operation on 110-volt, 60-cycle alternating current, which will be suitable for use in taking steel particles from the eyes. If possible, we would like to know of some method of controlling the strength of this magnet which can draw up to 60 amp.

Chicago Heights, Ill. J. E. G.

* * * *

Trouble with Generator—Will some reader please answer the following questions? (1) We have two generators and when I synchronize and cut in No. 2 generator in the morning before the load comes on, the lights around the board grow quite dim, although the voltage holds up well, around 2,400. When the load comes on the lights become bright. When I run one unit at night and a pump load of about 32 amp. is thrown on, the voltage drops to 2,150 but the lights are very bright. The lights grew so dim this morning that I thought I was losing the load although the voltmeter read 2,400 and the board showed only a small load. Does the power factor have anything to do with this? Can I figure the power factor from our board? We have one voltmeter reading 2,400 volts and two ammeters showing about 75 amp., on one generator and 78 amp. on the other. (2) When both generators are running together and everything seems normal, we often hear a sort of groan, about the same sound as a short circuit on No. 2 generator. Once I was standing on the base of the generator when it gave this groan and I could feel the sound or vibration. The generator does this frequently when running with the other unit but no indication of anything wrong shows on the board. Could it be that it slows down while in step and the load on the generator changes without showing on the board?

Canmore, Alta., Can. V. H. L.

Answers Received To Questions Asked

In the October issue of INDUSTRIAL ENGINEER we noticed several answers to question asked by J. U. regarding the best way to remove insulation from enameled wire. Having read all of the answers we thought that a description of the method which we use might be of interest to your readers.

In our rewinding work we use enamel-and-cotton-covered magnet wire exclusively, and of course it is necessary to remove the insulation from all of the coil ends so that they can be easily soldered. We do this by holding the wire in the flame of a blow torch until it becomes red. This will burn off all of the insulation, and while the wire is still red hot we immerse it in wood alcohol. The wire comes out of the alcohol perfectly clean. In the case of small wires it is necessary to be very careful, otherwise the wire will melt. With wire of No. 18 gage or larger no trouble will be experienced. We have tried various ways of removing enamel insulation and find this to be the most satisfactory.

KOONTZ BROS. ELECTRIC CO.
South Bend, Ind.

* * * *

Operating Two-Phase Induction Motor on Three-Phase Circuit—I should like to know if a two-phase induction type or squirrel cage motor can be run on a three-phase circuit, keeping the same speed and pulling the same load. I should like very much to have someone give me a diagram of such a hook-up and state if the two finishing ends of both phases or the start of one phase and the finish of another are hooked together. On what principles will the motor operate?

Chicago, Ill. J. H. B.

In answer to J. H. B. in the October issue of INDUSTRIAL ENGINEER who wishes information on running

a two-phase motor on a three-phase line:

The connection which he mentions is only a change from two phase, four wire to two phase, three wire.

I would refer him to page 6 of INDUSTRIAL ENGINEER for February, 1923, where the General Electric Co. advertises the type M. T. Q. auto transformer for changing three phase circuits to two phase, or *vice versa* to meet just such a condition as J. H. B. mentions.

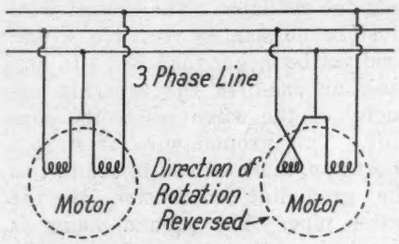
I think the only other practical way would be to open up the motor and reconnect the coils for three phase. This incident leads me to mention that, personally, I get almost as much education from the INDUSTRIAL ENGINEER'S ads as from the text, and that's saying something. ELLIOTT M. GASKILL.

Chief Electrician,
Empire Steel & Iron Co.,
Wharton, N. J.

* * * *

To the question asked by J. H. B. in the October issue of INDUSTRIAL ENGINEER, I would say that it is not very practicable to run a two-phase motor on a three-phase circuit, for the reason that the phases are of a different displacement on a two-phase circuit than on a three-phase circuit. In the former they are displaced 90 deg. while in the latter they are displaced 120 deg. In testing induction motors I have quite often run two-phase motors on a three-phase line in order to check them for end play and mechanical balance when our two-phase lines were in use. A motor can easily be run up to speed in that way for such checking, but it will take a larger current and it cannot pull the load that it would on a current of the proper displacement. If I wanted to use a two-phase motor on a three-phase line I would arrange to start the motor on the three-phase line and as soon as it was up to speed, open up one phase and run it single-phase, at which it should carry 60 to 70 per cent of rated load without trouble.

As to the last question, I will say that the principle of operation is the same as normal except that on account of the difference in the phase displacement the stator and rotor poles do not coincide with each other as they travel around. That is, at the same frequency the speed of the motor will be the same but the magnetic flux will be distorted by the difference between 90 and 120 deg. The motor has a good starting torque but when running it acts one instant as a motor and the next instant as a generator. Under actual test a 3-hp., 220-volt, 1,140 r. p. m., two-phase, 60-cycle, squirrel-cage motor took just about full load current when running idle on a three-phase, 220-volt line, the current being 5.5 amp. in one phase and 7 amp. in the other phase. The hook-up is very simple, as is shown in the accompanying sketch.



Connections for operating a two-phase motor on a three-phase circuit.

PHILIP G. BERNHOLZ.

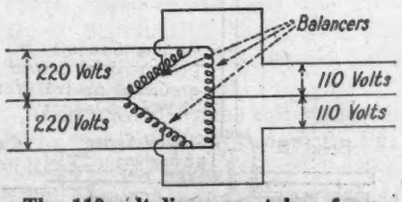
East Orange, N. J.

* * * *

How to Secure 110- and 220- Volt Service from 220-Volt Generator—We have a 7.5 kva., 3-phase, 220-volt, 60-cycle self-excited a. c. generator that we desire to use at night for lighting the boiler and turbine room and some residences across the street. I would like to have some reader tell me what transformer connections I can use to obtain 110 or 220 volts on the secondary side, so as to balance the load on all three phases. Would it be possible to use a balance coil with a three-wire secondary? If so, I would like to see a diagram of connections that will be most satisfactory.

Henderson, Ky. J. M.

When J. M. asked in a recent issue for a transformer or balancer connection to give him 110 and 220 volts on the secondary side and said that he wished to keep the load down, I assumed that there was to be a full load on the machine. If this is true the best balancer connection would be to put balancers across all phases, as shown in the illustration, and supply the load from the three centers of the balancers. If the greater part of the load is across the street, it would be better to put the transformers over there and run one neutral or 110-volt line back to the boiler room. This circuit has the advantage that the transformers do not have to be of the same voltage to get the balanced 110 volts as the only requirement is that the wire be large enough on the balancer to carry the current. For instance, a 440-volt winding with the neutral brought out can be used if the wire on the core is large enough. This may enable you to use any transformer that may be handy. If there happens to be a spare balancer handy there would be no need of running the neutral back to the boiler house as it can be gotten from this fourth balancer which would be located in the boiler house.



The 110-volt lines are taken from the centers of the three balancers placed across the phases.

If I am wrong in the assumption that the machine is fully loaded, it would probably be advisable for you to cut the field of the generator down so that the output of the machine is around 115 volts. This would eliminate the expense of installing transformers, but it would also cut the capacity of the generator to about half of its normal rating.

Buffalo, N. Y. R. M. BEECHER.

* * * *

Derivation of Chord Factor—(1) In his answer on rewinding a motor for four speeds, A. C. Roe says, on page 212 of the April issue: "Assuming a 1 and 12 pitch the chord factor is .99144. . . . . Then the voltage per turn for full pitch will be (127x1.009) divided by 104 . . . . . For a 1 and 10 pitch the chord factor is .92388, and full pitch voltage per turn equals (127 x 1.076) divided by 104 . . . ." I should like to know how the values 1.009 and 1.076 are derived, as the chord factor differs from the values given.

(2) In A. M. Dudley's book, "Connecting Induction Motors," there is given on page 187 the output coefficient values for 4, 8, 10, 12, 16, 20 and 24 poles. What values should I use for 2, 6, 10, 14, 18 and 20 poles?

Santa Barbara, Chihuahua, Mex. F. R. G.

In reply to the question by F. R. G., the value 1.009 is derived by subtracting the chord factor from one. This method of calculation introduces a slight error but is quicker than finding full pitch voltage, which is volts at any pitch divided by the chord factor for that particular pitch. In the case of the 1 and 10 pitch, full pitch voltage equals $127 \div 0.92388 = 137.4$. Then $127 \times 1.076 = 136.65$, or a difference of $137.4 - 136.65 = 0.75$ volts which, for practical purposes, is negligible. The same reasoning applies also in the case of the 1 and 12 pitch.

For the coefficient values for two poles, use twice the four-pole value found from the table in A. M. Dudley's book "Connecting Induction Motors." For six poles, use twice

the 12-pole value. For ten poles, use twice the 20-pole value. In other words, figure the rating out as for a 6-pole motor; then multiply the results by two, which is close enough. For fourteen poles, figure out as for twelve poles and multiply the result by 0.85. For eighteen poles figure as for twelve poles and multiply by 0.66. In each case check the iron below the slots and the teeth as explained by Mr. Dudley. A. C. ROE.

Detroit, Mich.

* * * *

Requirements for Grounding Conduit—I would like to get some information on practice in grounding conduit. Has the section of the National Electrical Code, 1920 edition, paragraph F on page 27 of section 12 on wires covering class B outside work been changed? I refer to the ruling regarding short lengths of conduit for entrance wires. Formerly where only a few inches of conduit were used to make an entrance it was not required to ground this conduit, providing no conduit was used inside the building and the voltage was less than 150 volts. We are now required to ground all such conduit to a 1-in. gas pipe, which seems unreasonable and adds at least four or five dollars to the job. I would like to hear from other readers who have run into requirements of this kind.
Good Hope, Ill. V. W. M.

In answer to V. W. M's question in a late issue, according to the National Electrical Code, Rule 12f, paragraph 3, conduit containing no conductor of a circuit exceeding 150 volts to ground, may be left ungrounded if insulated from the ground and from the metal conduit, armored cable or metal raceways within the building and from all metal work on or in the building. It is not necessary, although desirable, to ground entrance conduits. This is in effect the meaning of the rule. However, various cities have made it compulsory that entrance conduits be grounded. This is to minimize life hazards. Any entrance conduit may accidentally become charged to a high potential due to the circuit it contains becoming crossed with high-tension wires out on a pole. Any person touching such a charged conduit may, if the conduit is ungrounded, be electrocuted. An unnecessarily large number of accidents due to this condition has been reported. If the conduit is grounded the fatality will not occur and it seems to me that any expense that can be charged to an item which increases safety is well worth adding to the cost of a job. In any event it would be only a small part of the total cost. MARTIN T. LANE.

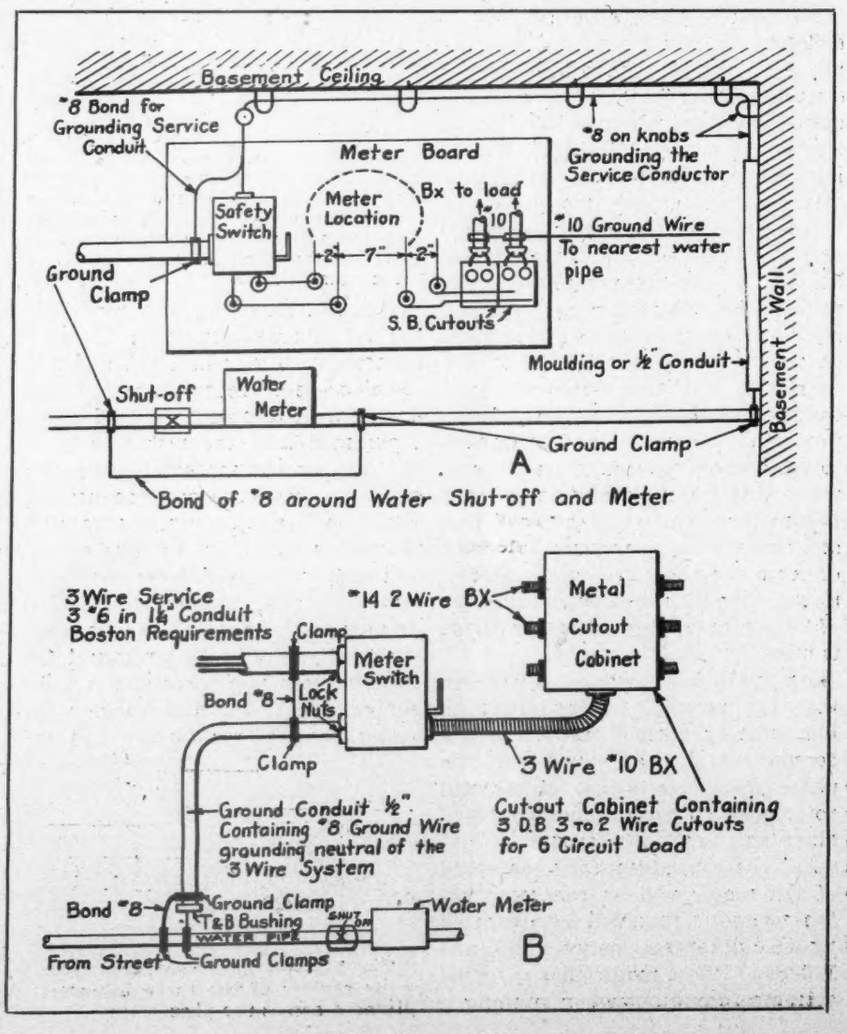
Denver, Colo.

In a recent issue of INDUSTRIAL ENGINEER V. W. M. asked for experiences in grounding entrance conduit. In Boston, Mass., the inspectors require one service wire to be grounded to a water pipe; a gas pipe must not be used unless it is the only one available. The ground wire must be no smaller than No. 8 and need not be larger than No. 4 in any case, or one-fifth the carrying capacity of the wires inside the conduit. This ground wire, if it is a short run, must be run in conduit to the grounding connection on the water pipe. The ground clamp is attached to the water pipe on the *street side* of the water meter or shut-off. The conduit containing the circuit ground wire is then bonded to the water pipe. This makes two ground wires, in effect, with the conduit used as a ground conductor.

In Cambridge, Mass., two separate ground wires are required, one for service entrance conductor and one for the service entrance conduit. In both cities the ground must be on the street side of meter or shut-off.

In other cities and towns one ground wire is run just as any wire is installed, protected by conduit or molding where it comes down on the wall. One end of this ground wire will be attached with a ground clamp to water pipe or gas pipe on the street side of meters and the other end is connected to one service wire. Then a short bond is made from the service conduit to the ground wire, which thus serves as a ground for both service conductor and service conduit, as in *A* of the illustration.

Where conduit is used containing the ground wire, it is run from the safety entrance switch or meter switch, both of which are in iron boxes having conduits attached in the usual way with lock nuts and bushings. But where the conduit containing the ground wire is also used as a ground conductor, by bonding to a water pipe, a jumper is



***A* shows a typical suburban service with open meter loop, eastern Massachusetts. *B* shows a typical, totally-inclosed, overhead service entrance, eastern Massachusetts.**

often put on around the safety or meter switch from the service conduit to the conduit containing the ground wire, as in *A*.

In any case the BX used in the house circuit is bonded together at the meter board with No. 10 wire, and one or more lines of BX grounded to the nearest water pipe, usually in the basement.

In underground service no service grounds are required, but the house lines of BX must be bonded and grounded as usual. All cutouts in Boston must be in a metal box. The accompanying illustration shows typical examples of requirements in Boston and the suburbs. The ideal service entrance is shown in *B*.

Boston, Mass. EDWARD A. GIBBS.

* * * *

Reducing the Speed of A. C. Motor—We have a 20-hp., 440-volt, 3-phase, 60-cycle, 1160 r p. m. motor having 36 coils. Each coil has ten turns of two No. 11 wires. The coils lay in slots 1 and 11 and are connected in series-star. We want to change this motor to operate at 860 r. p. m., 440 volts, 3-phase, 60-cycles, and still develop 20 hp. with seventy-two coils. The stator is 13 in. in diameter with seventy-two semi-closed slots ⅝ in. wide by 1⅛ in. deep. The core width is 6 in. We have already wound this motor with seventy-two coils made of five turns of two No. 11 wires. The coils were placed in slots 1 and 8 and the group connected in series-star. On testing the motor we found that it ran 900 r. p. m. but took 44 amp. at 480 volts running idle, although it did not heat up much. Will some reader please tell us what size wire and how many turns per coil we should use?

Mansfield, Ohio. C. E. P.

In reply to C. E. P.'s question as given above in INDUSTRIAL ENGINEER with reference to rewinding a 20-hp. motor for lower speed, I would suggest that he always keep in mind the fact that in lowering the speed of a motor the counter e m f is lowered and consequently a larger current is drawn. To keep the line voltage back and decrease the current, a higher counter e m f. is needed, therefore, a greater number of turns of wire, for a lower speed.

In rewinding this motor put in thirteen turns of two No. 12 wires. Span 1 and 8 and connect series-star for eight poles, which will give you 900 r.p.m. at 60 cycles. The motor will no doubt develop slightly less horsepower, but it is the best you can do when lowering the speed of a motor, as it takes more iron and, therefore, a larger motor for a given horsepower at low speed than at high speed. H. A. NEILSEN.

Dynamo Electric Works,
Los Angeles, Calif.

Answering C. E. P.'s question in a recent issue, I offer the following:

If C. E. P. is able to get twelve turns of No. 11 wire in each slot and winds with seventy-two coils, throw 1 and 8, and connects them in series-delta, he will have a very satisfactory motor. However, the horsepower will be 17.25 instead of 20. If he is unable to get twelve turns of No. 11 wire per coil and must use No. 12 wire, he will have a 14-hp. motor. I believe that he can get twelve turns of No. 11 with the size slot he has. Practically, it is not possible to reduce the speed of an induction motor and keep the horsepower the same.

While I have no connection with the selling of books, I am quite sure that C. E. P. would find Dudley's "Connecting Induction Motors," published by the McGraw-Hill Book Company, to be a very interesting, practical and readable book on the subject of induction motor windings.

J. W. MURRY.

Ohio Valley Electrical Repair Works,
Moundsville, W. Va.

* * * *

Changing Winding of Induction Motor—What changes should be made in rewinding a three-phase, four-pole, 220-volt, 20-hp. induction motor for operating on a two-phase, 440-volt circuit? The original stator has 48 slots with 48 coils of 14 double turns of No. 14 wire connected two-circuit delta with a throw of 1 and 10. What would be the result if only the throw of the coils is changed to 1 and 12?

Fairfield, Me. M. D. B.

The motor in question will have to be rewound as follows: Since it is connected two-parallel delta for 220 volts, the series-delta voltage would be 440. There being 48 coils and slots, there will be 48 divided by (4×3) equals 4 coils per group for the three-phase winding and 48 divided by (4×2) equals 6 coils per group for the two-phase winding.

With a coil pitch of 1 and 10, the chord factor either two-phase or three-phase equals 0.92388. If the coil pitch is kept the same the chord factor will not be used in the calculations. The three-phase distribution factor for four slots per pole per phase equals 0.958, and the two-phase distribution factor for six slots per pole per phase equals 0.890 approximately.

Then with the same coil pitch and turns per coil, the two-phase line voltage should be 440×3÷2×0.890÷0.958 equals 613.14 volts, which is 39.3 per cent higher than the required 440 two-phase voltage. This means that the total turns per phase will have to be reduced. The required two-phase turns per coil equals 14×440÷613 or 10 turns.

The size of wire will have to be increased. The current per coil was equal to (line current divided by 1.73) divided by 2, for a two-parallel delta connection. The full-load line current for a 20-hp., 440-volt, three-phase motor is approximately 27 amp. Then the amperes per coil equals 27÷1.73 equals 15.6 amp. There were two No. 14 wires for the three-phase winding. These have a cross-sectional area of (2×4107) equals 8,214 circ. mils. Then 8,214 divided by 15.6 equals 526 circ. mils per ampere.

The full-load current for a 20-hp., two-phase, 440-volt motor is approximately 24. Then allowing the same current density, the two-phase wire size equals 526×24 or 12,624 circ. mils. Using two wires in hand to make a flexible coil the size of wire equals 12,624÷2 equals 6,312 circ. mils or two No. 12 double-cotton-covered. Using three wires in hand, 12,624÷3 equals 4,106 circ. mils or No. 14 wire.

The old winding had fourteen turns of two No. 14 double-cotton-covered, 56 wires per slot. The new winding would have 10×3×2 equals 60 wires per slot or four more wires than the old. However, by using single - cotton - and - enamel - covered wire the coil will wind.

The two-phase winding data would be 48 coils each having ten turns of three No. 14 single-cotton-and-enamel wire, pitch 1 and 10, series connected, six coils per group, 20 hp., four poles, 440 volts, two phases.

Satisfactory results would not be obtained by merely changing the pitch to 1 and 12 and reconnecting. To reconnect the winding into two-parallel for two phases and change the coil pitch to 1 and 12, would require a line voltage of 306.5×0.99144 ÷0.92388 equals 328.88 volts, 0.99144 being the chord factor of the 1 and 12 pitch. If the motor were put on a 440-volt line it would be operating on 34 per cent overvoltage. Also as there would be six coils per group in place of four, the phase insulation on the beginning and ending of each pole phase would be out of place which would weaken the winding.

Taking all points into consideration, it would be good policy to rewind for 440 volts, two-phase.

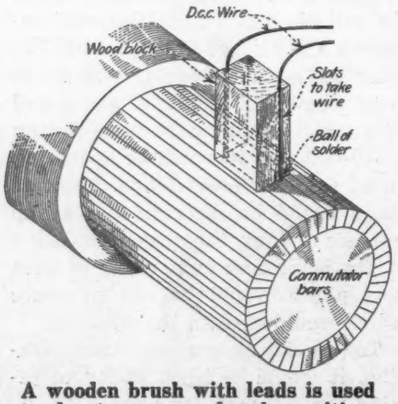
Detroit, Mich. A. C. ROE.

SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

How to Find Proper Position of Brushes on Commutator

A METHOD of finding the exact point for the brushes to rest on the commutator, applicable to both motors and generators, is shown in the accompanying sketch. In a direct-current machine there is a reversal of current in the armature coils as they pass under the brushes. This reversal is due to the fact that the current in the coil approaching the brush is flowing in one direction and after the coil has passed the brush the current flows in the opposite direction. Just at the instant of passing the brush the coil is short circuited. When the coil is short circuited a current is induced in it which cannot flow out anywhere and that is why the brushes must be placed so that this induced current will be of the smallest value possible; otherwise when the coil comes from under the brush there will be a spark due to the voltage forcing this induced current into the coil adjoining, the spark occurring at the brush just as the closed circuit is opened. When a motor or generator is loaded heavily an additional strain is placed on the machine if the brushes are not set properly.



A wooden brush with leads is used to locate proper brush position.

The only method in popular use for finding the proper point of brush position is to shift the brushes by moving the rocker arm first one way and then the other until sparking occurs, then bringing it back and allowing it to rest at the point in the center of these two places where sparking occurred. There are many times, however, when it will be found that there are as many as ten or twelve bars over which no sparking occurs, particularly if the machine is not heavily loaded. The center of this point is, of course, where the brushes should rest, but while the machine is running it is difficult to place them exactly in the correct position. Therefore the following method should be used:

Take one of the brushes out of the holder and make a block of soft wood just the size and shape of the brush. Have it fit the holder snugly. Cut a hack saw slot about ⅛ in. deep on each side of the block, spacing them so they come on bars next to one another. Take two long pieces of double-cotton-covered wire that will fit tightly in the hack saw slots. Push the wires in the slots so that they will not touch the sides of the holder and let them extend about 1-16 in below the bottom of the block. Bend these two ends toward one another and put a small drop of solder on each. Connect a voltmeter, or preferably milli-volt meter with an adjustable shunt, to the two leads.

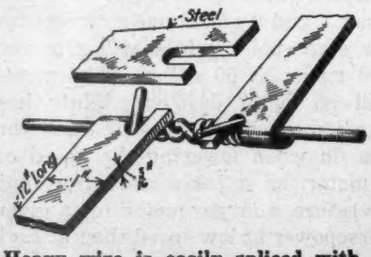
By moving the rocker arm first one way and then the other a reading on the meter will be shown in both directions. The absolute neutral point is where the deflection is slightest, because at this point there is the smallest amount of induced current in the short-circuited coil when under the brush.

Darby, Pa. GEORGE WM. HANLON.

How to Make a Jointing Tool For Heavy Wire

CONSIDERABLE effort is required to make joints with wire, and especially iron wire. Ordinary pliers will not handle the heavier wire and when large pliers are used the corrugations on them tend to cut into the joint and weaken it. The wire benders shown in the accompanying sketch are effective and simple enough to warrant adoption for the numerous instances when it is required to join sections of such wire.

Two of these tools are used and they are exactly alike. They will



Heavy wire is easily spliced with these tools.

make a solid and workmanlike splice in any size wire. Each tool is made from a foot length of flat steel, 1 in. wide and 3/16-in. thick. The end is bent to form a lip and one side is cut out as a bender for the wire. The illustration shows the method of using these tools. G. A. LUERS.

Washington, D. C.

Third-Rail Construction for Electric Transportation in Steel Plant Yards

IN DISCUSSING the electrification of the yard of the steel plant at the recent meeting of the Association of Iron & Steel Electrical Engineers it was pointed out that the third rail lends itself more readily to steel plant yard electrification than an overhead trolley because it does not interfere with the work of locomotive cranes and it is better able to handle heavy operation at low voltage. For yard work where switchmen and plant employes may not be denied free and safe passage over all portions of the yard, the bottom contact system of third rail is preferable to the top contact system.

[The following is an abstract of the paper which was presented on this subject.—EDITORS.]

The third rail should be set as low and close to the track as possible and be covered with impregnated wood or other insulator, so that its bottom and about ¾ in. of its lower vertical surfaces are disclosed. Placing it low makes it easy to step across and with the insulated cover, it can be stepped on without danger. Locating it as close to the track as clearances of the rolling equipment will permit, makes it easier for the contact equipment to cross switches and crossings and enter buildings.

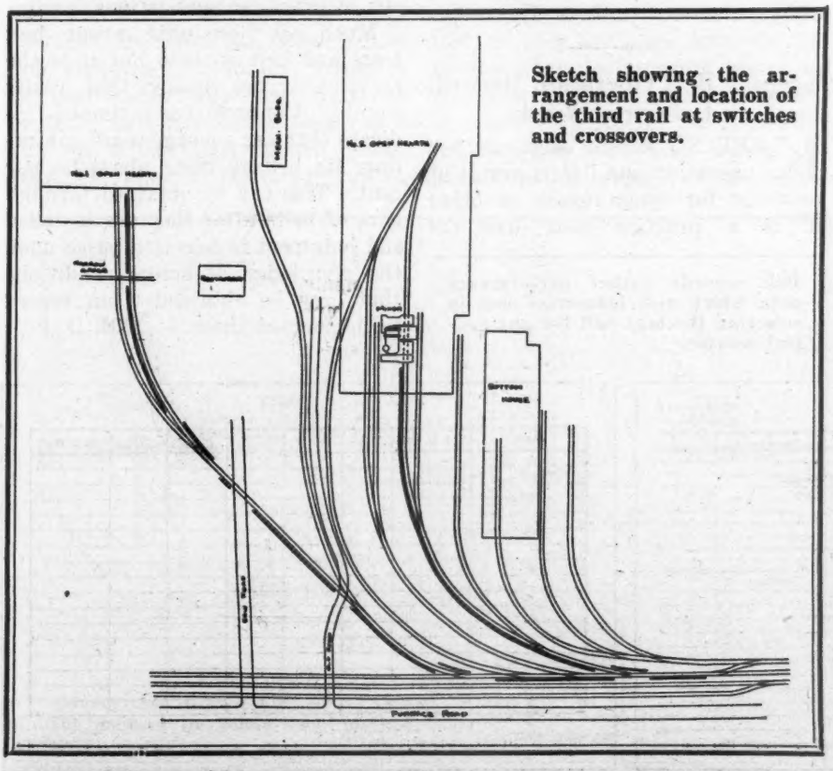
There are two methods of crossing switches, one by using a side approach fitting on the rail to guide the shoe into the contact position and the other to use an idler car to carry contact shoes, thus practically making the locomotive long enough to span any road or switch crossing. Since many of the operations about the steel plant require the use of a safety car, this is no burden and in any event if compared to the steam unit is more economical to haul and maintain than the tender. It is questionable if the idler car would be necessary with the two-unit locomotive where contact shoes would be applied at all four corners. Either the two unit or the single-unit locomotive and idler car will, of course, require contact shoes at each corner of the equipment.

The steel plant yard probably represents the hardest service of any industrial haulage. Its collector system is also subjected to a comparable service. The insulator and protective insulation must withstand hot metal and slag spillage. It must also be substantially built to withstand mechanical injury from spillage, and from badly-loaded refuse or scrap cars.

About 1,900 feet of under-hung bottom contact third rail was placed in steel mill yard service in a certain steel mill May 31, 1923. This is a 250-volt straight electric installation, current being supplied through automatic reclosing circuit breakers from the existing power system. The installation of the third rail cost $2 per ft., distributed as follows:

Rail	17	per	cent
Insulators	12	"	"
Guard	10	"	"
Brackets	5	"	"
Bonds	5	"	"
Miscellaneous bolts, wire, etc.	11	"	"
Labor	40	"	"

As most of the work was pioneering and done at odd times, it is felt the figure on labor could be bettered on future work. The accompanying sketch shows the arrangement of the third rail for switches and crossovers. With the exception of the bakelized canvas insulator, all the material was produced or fabricated in this plant. The rail is a "bullhead" section of 3-in. x 3-in. soft steel billet which lends itself readily to bending in order to follow the track curvature. The supporting bracket is a piece of ¾-in. by 8-in. sheet bar, bent to the shape desired. The wood guard fastened together by bolts and rails is easily built by any rough carpenter.



Sketch showing the arrangement and location of the third rail at switches and crossovers.

The center line of the third rail is located 34 in. from the center line of the track and its conducting face 2¾ in. above. With practically nothing hot but the bottom surface, with a voltage that most plant employes are more or less familiar with, because of handling drag wires on locomotive cranes, crabs, and so on, it is felt that the hazard of severe accidental shock is reduced to the minimum. In fact, after three months' service in the most crowded section of the plant yard where clean-up gangs work quite often there have been no cases of flashes or shocks reported to date.

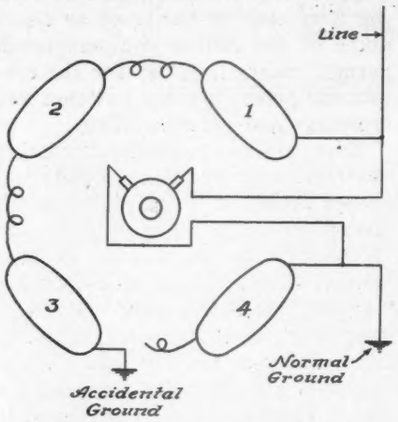
Three months' operation of the third rail on hot metal work has resulted in only two failures, one from the derailment of a truck which required repairs to both track and third rail, and the other from grounding of a rail insulator by hot metal spillage. This failure presented a point that had been overlooked and was later remedied by the addition of one more piece of wood guard. From results obtained so far it would appear that the adop-

tion of a third rail over the entire plant would be satisfactory with possibly the addition of cable reels for use on open-hearth charging floors and shops where the physical location of the rail may be objectionable. The locomotive used on this installation is a homemade rigid frame motor car to which two 75 hp. (½ hr. rating) back-geared, mill-type motors were adapted. F. O. SCHNURE.

Electrical Engineer,
Bethlehem Steel Co.,
Sparrows Point, Md.

Grounded Field Coil Connection Increased Motor Speed

SOMETIMES it appears to take very little to render a motor inoperative; how a motor can, at other times, operate under existing conditions is a wonder. We had a 600-volt, 4-pole, direct-current, shunt-wound motor driving a blower for supplying the air for twelve downdraft blacksmith forges. One day the foreman of the blacksmith shop remarked that "the air is much better than it used to be." As the improvement was attributed to general improvement in voltage conditions, no attention was paid to the remark at the time. A few days later, however, the maintenance man having occasion to lace the belt which connected the motor to the blower, noticed that the armature turned faster than usual, the frequency of the sound made by the lacing as it passed over the pulley of the blower calling the higher speed to his notice at once. No sign of sparking appeared at the brushes, vibration appeared to be even less than usual and there was absolutely no throwing of oil. There was no outward indication of trouble excepting the noticeably higher speed, notwithstanding the fact that the motor operated in a dark place where an increase in sparking would have been readily noticed. Investigation disclosed the condition indicated in the accompanying diagram. One side of the motor was normally grounded, as it was a ground return circuit. Between the normally grounded field coil, No. 4, and the coil



Field coil No. 4 was cut out by the accidental grounding of the connection between it and No. 3 field coil.

next to it, No. 3, the connecting wire had been forced loose, probably by someone stepping on it, and its bared end was making good contact with the motor frame, thereby cutting out No. 4 field coil entirely.

The armature was of the series-connected type, having only two paths through it from brush to brush. Had it been of the multiple-connected type, having as many paths as poles, undoubtedly the resulting unbalancing of armature current among the several paths would have caused vicious sparking.

Brooklyn, N. Y. J. A. HORTON.

Keeping Belt Operation Records in Industrial Works

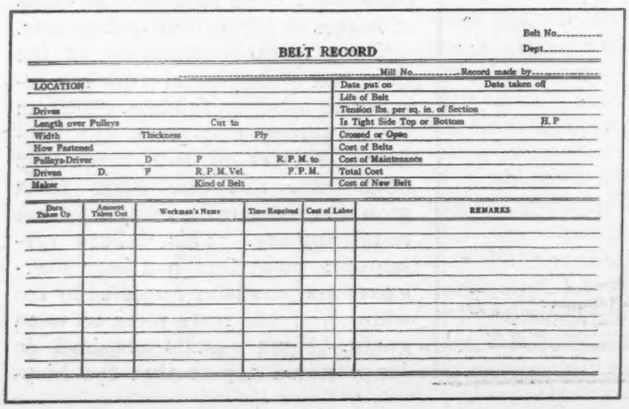
KEEPING record cards on belt operation and life is not at all new but for some reason or other it is a practice that has not been adopted by anywhere near as many industrial plants as could do so with profit. Transmission belting has so much to do with production that every superintendent should have a recorded knowledge of the service that may be expected of various types and grades of belts on different classes of drives. It is not necessary for him to keep a card for every belt in his works but he should at least keep a record or two of every class of belt drive and should always keep records of larger or more costly installations. In this way it is not only possible to know what the different belts are doing but such a record also facilitates the comparison of two types or grades of belts. All lines of industrial work do not require the highest-grade belting. However, without some record it is not always practicable to judge whether the second grade of belting will be satisfactory. Whenever the belt record shows that a belt has a very short life it indicates the need of locating the cause.

Belt records gather performance data which aids industrial men in selecting the best belt for any special service.

Plant operatives who desire to keep belt records may secure a supply of belt record cards upon request from many of the prominent manufacturers of leather belting. The cards shown accompanying this item may be obtained from the Chicago Belting Company, Chicago, Ill. These are standard 8-in. by 5-in. cards and provide ample space for record purposes. These forms have been tried out in practical applications.

Much has been said about belt tests and belt quality, but it is the service on the pulley that really counts. Conservative estimates indicate that the average plant can reduce its belting costs about 25 per cent. This can be obtained through care of belts after they are installed and judgment in selection based upon the knowledge of actual conditions that may be obtained from record cards such as these. E. D. F.

Chicago, Ill.

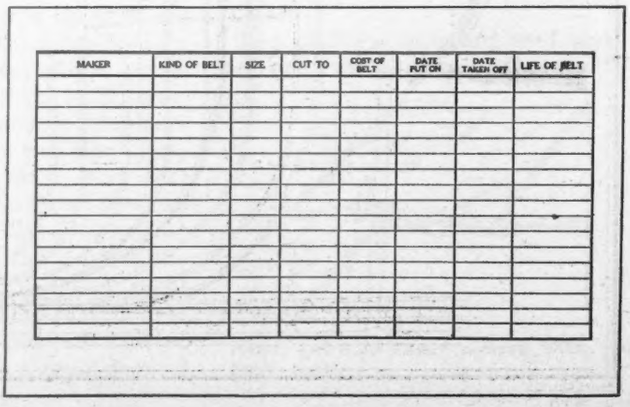


BELT RECORD

Belt No.
Dept.
Mill No. Record made by

LOCATION		Date put on	Date taken off
		Life of Belt	
Driven		Tension lbs. per sq. in. of Section	
Length over Pulleys	Cut to	Is Tight Side Top or Bottom	H. P
Width	Thickness Ply	Crossed or Open	
How Fastened		Cost of Belts	
Pulleys-Driver	D F R. P. M. to	Cost of Maintenance	
Driven D. F R. P. M. Vel.	F. P. M.	Total Cost	
Maker	Kind of Belt	Cost of New Belt	

Date Taken Up	Amount Taken Out	Workman's Name	Time Required	Cost of Labor	REMARKS



MAKER	KIND OF BELT	SIZE	CUT TO	COST OF BELT	DATE PUT ON	DATE TAKEN OFF	LIFE OF BELT

A Switchboard Which Simplifies Testing Motors by the Pump-Back Method

A SWITCHBOARD for testing alternating-current and direct-current motors and generators by the "pump-back" method has been in use for several years in the plant of an eastern motor manufacturer. The switchboard controls a 230-volt direct-current machine of about 75 kw. rating. This machine is belted to the machine to be tested and acts as a generator if the tested machine is a motor, and conversely, acts as a motor if the tested machine is a generator. Two field rheostats are provided for the 75-kw. machine. The high-resistance rheostat permits the machine to be used as a motor at its highest safe speed. The low-resistance rheostat permits fine adjustment of speed when running as a motor and fine adjustment of load when running as a generator. A no-voltage release acts as a safeguard.

If the motor to be tested is a direct-current motor, it is connected to the leads marked *A*, *F*, and *M* (armature, field, and main) at the bottom of the board. The motor to be tested may be either 115, 230, or 550-volt, as all three sources of supply are provided on top of the board. The 230-volt, 115-volt, and 550-volt direct-current generators supplying this energy are driven on the same shaft by a synchronous motor, so that no matter what combination of voltages are used, all power above that required to supply losses is pumped back in the line. Only one of these switches can be closed at a time or a short circuit will result. However, as only one motor can be under test, there is very little danger of two switches being closed at the same time. The two studs *F'* and *F''*, which are in series with the field lead, are used for inserting a field rheostat. A permanent field rheostat on the board would not provide sufficient flexibility where various sizes and types of motors are tested.

After the motor under test is connected up and proper pulleys have been selected for both the motor and generator, one of the three top switches is closed, depending on the voltage of the motor under test. The double-throw switch *R* is then closed to the testing position, which places the starting resistance in the armature circuit of the motor under test. The same starting resistance is used for both the motor under test and the generator. The motor is then brought up to speed and the test switch *SC* (short-circuiting) closed. The rotation should be checked to see if it is correct and changed if necessary.

By changing the double-throw switch *R* to the "generator" position and closing the 230-volt generator switch, the generator can be placed on the line using the starting resistance. The load on the motor is watched, adjusting the generator field rheostat if necessary, to keep the load down. When the generator is on the line the load can be accurately adjusted. Portable instruments are used on the motor under test, as they are more accurate and flexible than instruments placed on the switchboard. It is not necessary to measure the load on the generator.

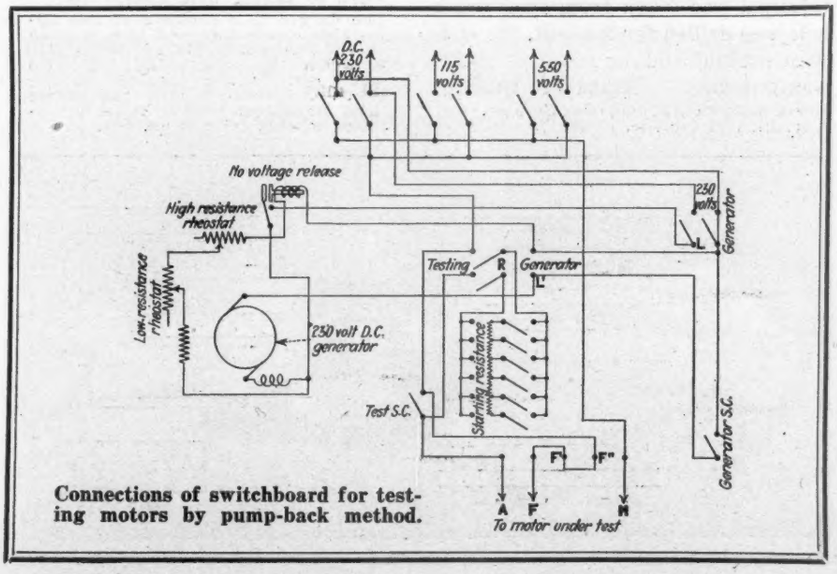
There are rare cases where the proper pulley combinations cannot be obtained to drive the generator at the correct speed for putting on the line and loading. In these cases the studs marked *L*, *L'* are connected to an external variable resistance for loading the generator. The 230-volt generator switch and the main switch with no-voltage release is closed so that the generator field is excited from the main line. All the power generated is, of course, in these cases, dissipated as heat and is a loss. It is, however, seldom necessary to resort to external loading, as by far the greater majority of cases can be loaded by the pump-back method in which only the losses of the motor under test and the generator have to be taken from the line.

Alternating current for testing an induction motor is obtained from a motor-generator set (not shown in the drawing) which consists of a direct-current motor driving a 60-cycle, alternating-current generator. The motor is driven from the direct-current main and is so arranged that it can be driven either from the 230-volt or the 115-volt supply which, with field weakening, provides various speeds so that motors of all ordinary frequencies can be tested from the same generator. In addition, the generator connections are brought to a terminal board provided with switches, so that the windings can be connected in series or in parallel and each combination can be connected either in star or delta. With field-excitation control, this gives a wide range of voltage.

In loading an induction motor it is necessary to note the pull on the belt, that is, which side of the belt should be tight when the motor under test is doing work as a motor, because only in this way can one tell whether the motor is running as a motor or an induction generator. The ammeter reading on the induction motor is the same whether the motor under test is doing work as a motor or a generator. With a direct-current motor the ammeter shows a reversed reading.

In testing a direct-current generator, it is driven by the 75-kw. machine and pumps energy into the line at 115, 230 or 550 volts, as desired.

An alternating-current generator likewise is driven by the 75-kw. machine and is loaded by connecting it to the alternating-current side of the motor-generator set.

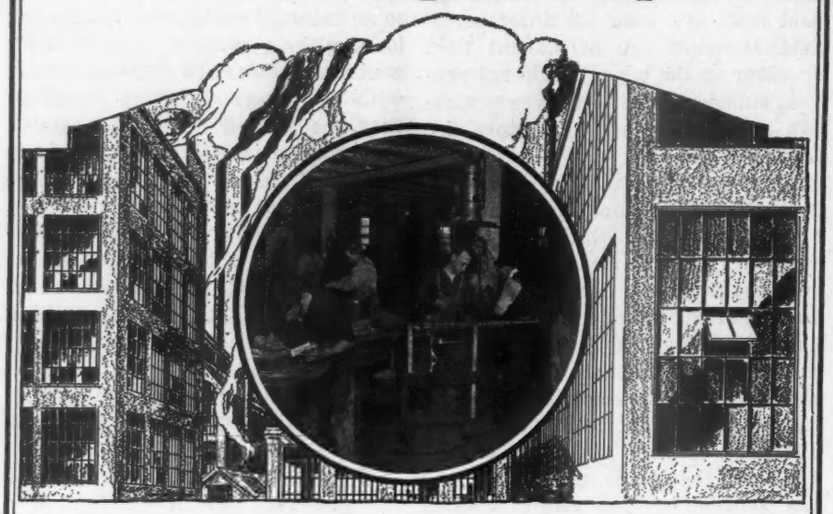


Connections of switchboard for testing motors by pump-back method.

EUSTACE C. SOARES.

Electrical Engineer,
Ophuls & Hill, Inc.,
New York City.

In the Repair Shop



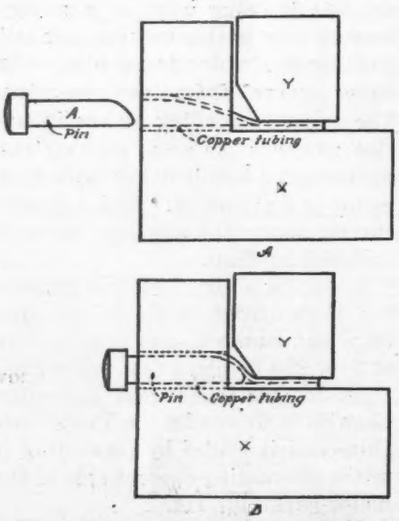
This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Terminals Made from Copper Tubing in Emergency

WE RECENTLY had occasion to use a number of copper cable terminals and were not able to secure them on short notice. In order not to hold up the work under way one of the instructors made the device shown in the accompanying illustration and then secured some copper tubing from a plumber and made the terminals. As shown, the block *x* is an L-shaped piece of cast iron through which was drilled a hole just large enough to receive the copper tubing and located so that one side came through flush with one of the inside surfaces of the L. A square cast-iron block *y* was finished off with a beveled edge. Lastly a steel pin was made of the shape shown and of the proper size to fit inside the tubing.

The tubing was cut into suitable lengths with a hacksaw. To form a terminal a length of tubing was inserted in the drilled hole until it was flush with the left-hand side of the block. Blocks *x* and *y* were then clamped in a vise to flatten one end of the copper tubing. This made the tube assume the form shown in *A*. The steel pin was then driven in the tubing to form the socket to its full diameter throughout the length of the portion in the hole. After the terminal was taken from the form a hole was drilled for the bolt, the ends were ground, and the inside of socket was trimmed. HARRY S. RUSH.

North Dakota Agricultural College,
Agricultural College, N. D.



The tubing was cut into suitable lengths, flattened at one end in the die and the socket formed by driving the pin into the other end.

Fixtures to Hold Field Coils While Being Taped

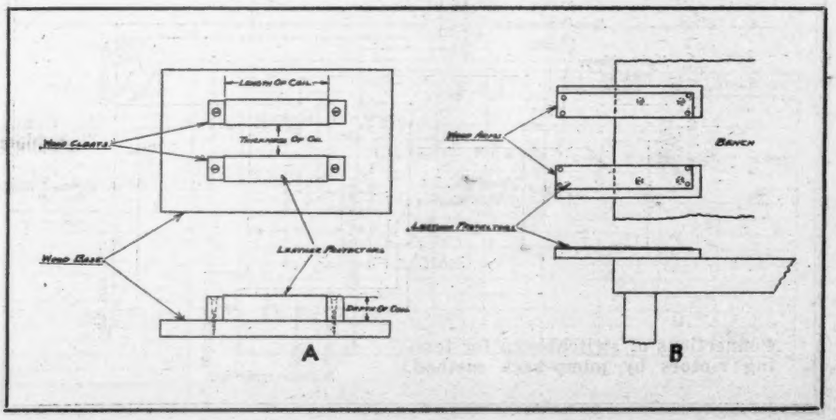
IN THE winding department of an Eastern manufacturing company, the taping of large motor field coils is expedited considerably by the use of the two fixtures illustrated and described below. Either one might well be adopted by the repair departments of factories or shops where the taping of a field coil on an ordinary bench is always an awkward job.

The first fixture, shown in *A*, consists of two cleats made of heavy wood, which is well seasoned to prevent warping or splitting, mounted on a wooden base. The cleats should be covered with leather. The dimensions are in proportion to the sizes of the coils handled. By using large, flat-head wood screws to hold the cleats the space between them may be adjusted to take coils of varying thickness. The coil is placed on its side between the two cleats where it is held firmly upright in a convenient position for applying the tape. When not in use the fixture is easily set back off the work bench out of the way.

Where a certain part of the work bench may be permanently set aside for taping field coils, the arrangement shown in *B* is very useful. In using this device the coil is laid flat on the two arms, spanning the space between them. It is moved around as the taping progresses. The two arms project out only a short distance—just far enough to permit the roll of tape to pass between the edge of the bench and the inside of the coil. The thickness and width of

These devices will speed up the work of taping field coils.

The fixture in *A* consists of two adjustable cleats fastened to a wooden base. The coil is placed on its side between the cleats. In *B* two wooden arms are fastened to the bench and the coil is placed across them for taping. The arms can be adjusted to hold coils of different sizes.



the arms are made to suit the sizes and weights of coils ordinarily repaired. The arms, being fastened to the bench with screws, are adjustable for various widths of coils. This device, where it is possible to use it, is preferable to the other because it places the coil on a better working plane and enables the operator to drop the roll of tape naturally downwards through the coil in making the round of the coil.

Honesdale, Pa. J. M. WALSH.

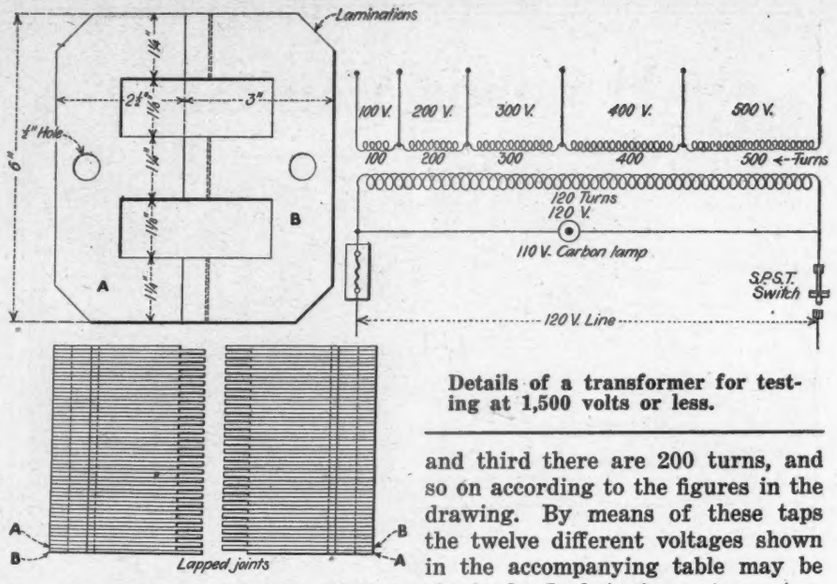
Construction Details of Transformer for High-Voltage Tests on Small Motors

THE transformer shown in the accompanying drawing and photograph was made for use in high-voltage tests on small motors. This transformer gives from 100 to 1,500 volts, with ten intermediate voltages.

For the core, laminations were secured of the shape shown in the drawing. One-half of these laminations are of the dimension shown at *A* and are 2½ in. wide, while the others are of the dimensions shown at *B*, and are 3 in. wide. The laminations were built up to a height of 4 in. One-half of the core was built at one time, the *B* laminations alternating with the *A* laminations. After the two halves were built up, they were bolted together with ⅜-in. bolts and the coils were put in place. Then the halves of the core were shoved together.

For the primary winding, a coil was made up of 120 turns of No. 16 gauge double-cotton-covered wire.

This transformer was made for testing for grounds and short circuits with voltages of from 100 to 1,500 volts.



Details of a transformer for testing at 1,500 volts or less.

For the secondary winding, No. 26 double-cotton-covered wire was employed. Altogether, there were 1,800 turns on the secondary winding. Six taps, including the end terminals, were brought out, as shown in the drawing. Between the first terminal and the second tap, there are 100 turns; between the second and third there are 200 turns, and so on according to the figures in the drawing. By means of these taps the twelve different voltages shown in the accompanying table may be obtained. In bringing out any tap, the wire should be insulated with a varnished cambric sleeve, if this tap is to be covered by further layers of wire. The core itself should be insulated from the winding by fiber or fishpaper, and the primary coil should be insulated from the secondary by the same material.

Taps for Different Voltages

Voltage Desired	Connect High-Voltage Leads to Taps Shown Below
100	1 and 2
200	2 and 3
300	3 and 4
400	4 and 5
500	5 and 6
600	1 and 4
700	3 and 5
900	4 and 6
1,000	1 and 5
1,200	3 and 6
1,400	2 and 6
1,500	1 and 6

After this transformer was built it was mounted upon a baseboard and another board with terminal posts for the secondary was mounted above the coils. In series with the primary side, a fuse block for using an open fuse wire was connected. Across the primary terminals a 110-volt carbon lamp was connected. This lamp is a safety feature, as it is lighted whenever there is voltage on the primary side. The primary leads were connected to a flexible cord having on its other end a detachable plug to fit in an ordinary 110-volt outlet. The secondary leads were flexible, heavily insulated wires. The high-voltage terminals were wires which were wrapped with varnished cambric and outside of this was placed rubber tubing.

In operation, if a ground or short circuit is detected by the secondary leads, the fuse blows. On touching the secondary terminals to the conductor and frame and removing them, a light blue snapping spark indicates only charging current and does not show a fault. A red or yellow flaming spark, however, shows that power current is passing and that a short circuit or ground exists, depending upon what is being inspected. Usually when there is such a short circuit or ground the fuse will blow. A. C. ROE.

Detroit, Mich.

Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

An Electric Truck with High Wheels Which Is Adapted for Inside Haulage and Also for Street Industrial Use

INDUSTRIAL plants which have much yard work, or where it is necessary for the truck to go some distance on the street, often find that an electric industrial truck with larger wheels than is ordinarily used on concrete driveways or factory floors gives better satisfaction. For example, the New York City plant of the International Tailoring Company uses such a truck to handle material in the plant and also to carry the mail to the post office a block away.

This company does a mail order business with thousands of retail tailors throughout the country. They send out large numbers of sample books, measuring charts and finished garments as well as a large amount of other mail. The volume of the parcel post became so great that three or four men with as many hand trucks had been required to take the mail to the post office. Finally, an electric industrial truck (Crescent Truck Co., Lebanon, Pa.), as shown in accompanying illustration, was installed. This was fitted with a special body, mounted on the platform of the truck, to take care of the mail bags. This body is made of steel and has a hinged door which opens into the single deep compartment. The truck body was designed to fit inside of the freight elevators of the building and is taken on to the elevator and carried to the ninth floor for its first consignment of mail in sacks. It is then lowered with its partial load to the shipping and cutting rooms on the second floor, where it picks up the packages of garments which are packed and ready for mailing. It is then run onto the elevator and lowered to the street level, the hinged door locked and it goes on its trip to the post office. This truck carries about thirty-five sacks per trip and ordinarily makes four or five trips per day. Frequently, when the mail is extra heavy, a trailer is attached. In this way one man has replaced the three or four formerly required for this work with a corresponding saving.

The truck used here is of 4,000 lb. capacity and has an extremely short body with an overall length of but 64½ in., which enables it to be used on a 66 in. elevator. Many plants, particularly the older ones, have small elevators and so are limited in the size of truck which can be used. This truck is also comparatively light, which is an additional advantage in using on elevators in the older type of buildings. The truck wheels are 20 in. in diameter with hard rubber tires which permits them to be used in the yards or on the street.

As may be noticed, when it is used on the street a truck of this sort must carry a regular commercial truck license. The batteries are guarded against damage by having coiled springs surrounding push rods on each side of the cradle which carries the battery. This eliminates much of the jar of the rough street pavements, thereby lessening the

This truck, with a special body is used to carry mail about a block, to the nearest post office. It also has an extra short body which enables it to be run onto the elevator and taken to the ninth floor for loading.

danger of damaging the battery.

Trucks with large wheels such as this are advantageously used in handling material over rough or loose ground. Of course, it is not possible to haul as large loads as if the yard were smooth concrete.

Lifting Mechanically the Unhandy Loads Without Blocking Up

ORDINARILY if a load is to be carried by truck it must either be placed upon a platform to be handled by lift trucks, either hand-operated or electric, or the loads must be raised bodily and set upon the truck. Some manufacturers now, however, are taking advantage of electric lift trucks which pick up and support the load on fingers extending out from the front of the truck. These may be raised and lowered as is the platform of an ordinary electric industrial truck, but their bottom position extends entirely down to the floor. The points of these fingers are chisel shaped at the outer end so that they may be inserted beneath a bundle, box, barrel, casting, or any other irregular shaped piece weighing up to 2,500 lb., and lifted clear of the floor. With this, it is not necessary to lift the weight entirely but merely have it resting even on narrow planks or tip it enough so that the chisel points can be pushed under.

One plant, for example, uses a truck of this sort (The Elwell-Parker Electric Company, Cleveland, Ohio) to carry crated goods, as shown in the accompanying illustration. The cleats hold the package

This truck has fingers or projections extending out in front which are run under packages and raised to carry the load.

up far enough from the floor so that the fingers may be slipped underneath, the load raised, and carried to its destination. The length of the fingers in various trucks depends largely upon the type of material to be handled, as it is not best to get them too long because the load on the truck is balanced over the front wheels against the battery box and the remainder of the truck.

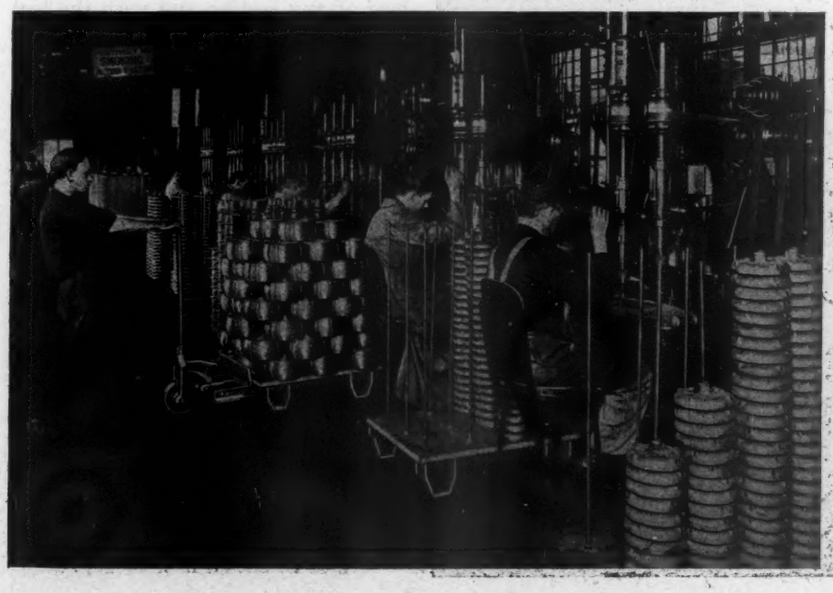
Bulk Handling Which Simplifies Movement to and from Machines

PROBABLY but few factories still use the old plan of dumping castings at one side of the machine for the operator to pick up, machine, and throw on the floor again at the other side. The unnecessary re-handling incidental to this was one of the earliest problems attacked in solving material-handling difficulties in industrial plants. It is now the practice in many plants where the work flows from one machine to another in a regular procession to place permanent benches between or, in some cases where the distance is greater, conveyors from one machine to the next. This plan, however, is only adaptable where there are but few changes in the work operated on by that one battery of machines.

In plants where a diversity of work may be handled by each of the machines, skids or platforms for hand or electric elevating trucks now generally take the place of the permanent benches, as is shown in the accompanying illustration. This illustration, taken in the drill-press department of a large electric motor manufacturer, shows one solution of this problem. Here the material is piled on these platforms and deposited beside the drill-press operator or removed when finished, by a "Transveyor" (Cowan Truck Co., Holyoke, Mass.).

Material which does not pile easily is stacked on spindles as shown. In some cases a filled platform of unfinished work is placed on one side of the operator and an empty platform to receive the finished work is placed on the other. However, with these trucks this is not always necessary. For example, one or two empty spindles may be left on a truckload of unfinished work to receive the pieces as they are finished. In this way the same platform may be used for both finished and unfinished work and so decrease the amount of floor space necessary between the machines. Where floor space is at a premium this saving is considerable. Also, in case of an emergency, the whole load may be removed and an entirely new line of work substituted if it should become necessary to change the piece on which the man is working.

In addition, this material, in case the man performing the next operation is not ready, may be stored on the truck platform until he is ready and thus eliminate any extra handling between operations. Methods such as this also help to keep a shop in order.



How a large electric motor manufacturer simplified the handling of miscellaneous work from machine to machine in the drill-press department.

Stubbing and Connecting Windings

(Continued from page 539)

found that lights out. Then mark these two leads as belonging to the same section and repeat until all four sections have been located.

The next step is to locate the two sections of one phase. Take any one motor lead and if it cannot be traced by the eye to the group it connects to, use the test light. Hold one test lead on the motor lead selected and with the sharp-pointed test lead test each group until a light is obtained. Then call this group No. 1 and counting over to the right to No. 3, test this group while holding the other test lead on the same motor lead as before. The test lead can be attached to the motor lead with a piece of tie wire. If a light appears on this No. 3 group, it is the second group of the first section. If no light appears then count over to the left to No. 3 and test. If a light appears then *this* is the second group in this section. Mark the two leads which connect to this section, leads 1 and 5.

A light on either of these No. 3 groups (to right or left) shows that the winding has a top-to-top or short-jumper connection. It is possible that neither of these groups will show a light. This would indicate that the winding has long jumpers (top-to-bottom connection). In this case the test should be made on group No. 5. A light on this group will show that it is the second group in the section.

Now that one section is located, the next step is to find the other section of the same phase. With the top-to-top connection this is done by starting at the last group in the first section which has already been located. Start on this group as No. 3 and pass from 3 to 5. The group 5 so found will be in the other section of the same phase. Keep the sharp point on this group and locate the two leads which are connected to it. Mark these leads 7 and 3. These four leads then, 1 and 5 and 7 and 3, locate one phase.

Now in order to be sure of correct connections later, the leads must be marked according to some diagram like that in *M* of Fig. 6. Taking the first section located face the machine and call one group of this section No. 1. One lead of this group will connect to one motor lead. Pull on this group lead until it can be located outside the motor. Mark this lead No. 1 and its mate No. 5. Then from group No. 3 count over to group No. 5. By pulling locate the motor lead which connects to this group. Mark this lead No. 7 and its mate No. 3. This gives one phase in its proper relation. Locate the second phase leads in the same way, marking according to diagram.

On a six-pole, two-phase motor there would be three groups per section instead of two as in the case just mentioned. Similarly there would be four on an eight-pole machine, five on a ten-pole, and so on.

In checking a three-phase, star winding the diagram in *N* of Fig. 6 may be followed as an example. Such a winding has nine leads. The winding is divided into four sections, one section has three leads and the other sections have two leads each. With the test lamp find the three leads belonging to the large section. Then keeping one test lead on one of these leads locate one of the groups in this large section. By pulling trace out this section until one of the motor leads connecting to the section is found. In a four-pole machine there are six groups in such a section; there are nine in a six-pole machine; twelve in an eight-pole machine, and so on. Then all the groups in this phase may be located as they are all separated by two groups belonging to the other two phases. By tracing around in this way the other section in this phase is located. Then by referring to the diagram the various leads may be marked as they are in *N* of Fig. 6.

The delta winding as shown in *O* of Fig. 7 is divided into three sections each having three leads. The first step is to light out the motor leads into three sections. The next step is to find the lead which has two groups connected to it. Take any lead of any section and with the test lamp locate a group in this section. By pulling follow up the groups in this section until the lead attached to two groups is found. Call this lead No. 1. Then by pulling the leads the other groups can be located. By working in this manner while consulting the correct diagram the entire winding may be checked and marked.

A winding arranged for star-delta connections like that in *P* of Fig. 7 is easy to check. There are three sections and each section contains all the groups in one phase. With the help of the test lamp the six leads should be divided into

Fig. 8—After soldering the jumper connections they are taped and formed as shown in *E* of Fig. 2.

three sets of two each. The groups of each section should be located by means of the pointed test lead. Then the diagram should be consulted with particular reference to the direction of the arrows. In place of arrows chalk marks may be made upon the stator core to represent direction of current flow. These should be straight marks made at each group and inclined inward in the direction in which the arrows point. After these marks are put on, the leads should be marked according to the diagram. If one of the phases is reversed the winding will have a "60-degree" connection instead of the correct "120-degree" connection. An explanation of the difference between these two kinds of connections is given in the article on page 491 of INDUSTRIAL ENGINEER for October.

Those who want to learn another method of testing out the double-voltage windings may refer to an article on "Connecting Induction Motors with Untagged Leads to the Line" by L. G. Tubbs in the November, 1922, issue of *Electric Journal*.

In a later article of this series in INDUSTRIAL ENGINEER explanations and diagrams will be given of two-speed and four-speed windings.

Circuit Breakers for D. C. Motors

(Continued from page 528)

shunt-trip coil of the second circuit breaker. When the first breaker opens the auxiliary switch will close and thus operate the shunt trip.

If desired the auxiliary switch can be so constructed that it closes the local circuit when the breaker is closed and opens it upon the opening of the latter. This form of switch is frequently used on a circuit breaker when it is desired that the opening of the same shall cause the opening of a second circuit breaker having a no-voltage coil. In this case the end in view is attained without the use of a shunt-trip feature by having the circuit of the no-voltage coil connected through the switch on the first or control instrument.

The instances cited will serve to indicate the manner in which these auxiliary switches or bell-ringing attachments may be employed to meet a variety of conditions.

Fig. 9 shows this auxiliary switch connected into a local circuit, so as to provide an alarm whenever the circuit breaker opens. While in the illustration a bell is shown as the indicating means, a semaphore, lamp, or other suitable device may be substituted to meet the requirements of the user. The indicator, whatever form is employed, may be located at any required distance from the circuit breaker, or several indicators may be placed at convenient points.

How to Keep Circuit Breakers in Proper Condition

Keep the joints and contacts of circuit breakers clean and tight and they will usually give no trouble. If a joint shows signs of heating (darkening of the copper) it should be tested. Heating may usually be traced to insufficient copper or poorly made joints at the back of the instrument; or it may be due to oxidation of the contacts resulting from lack of use.

The condition may readily be investigated by going over the joints in question with a milli-voltmeter or, if none is available, a Weston round-pattern ammeter (disconnected from its shunt) may be employed. The full scale of these instruments when used in connection with the leads supplied by the maker is approximately 0.050 of a volt, and the instrument may readily be equipped for the work in question by attaching a sharp needle point to the free end of each lead.

Where cables are attached to the circuit breaker by means of lugs, the joints associated therewith should be made the subject of especial scrutiny. Generally speaking, no single joint should show a drop over 0.003 of a volt when subjected to its rated load. The oxidation which may form on the circuit breaker contacts through lack of use and in the absence of self-cleaning action incident to frequent opening and closing, may readily be removed by the application of fine emery cloth to the surfaces affected.

When heating does occur, even though the causes be external to the circuit breaker, if these are not hunted up and removed the spring temper of the laminated member will be damaged and thereby introduce a further source of heating. Where this has been allowed to occur the installation of a new laminated member is the only remedy, and after this is installed its adjustments should be tested by means of the milli-voltmeter method described.

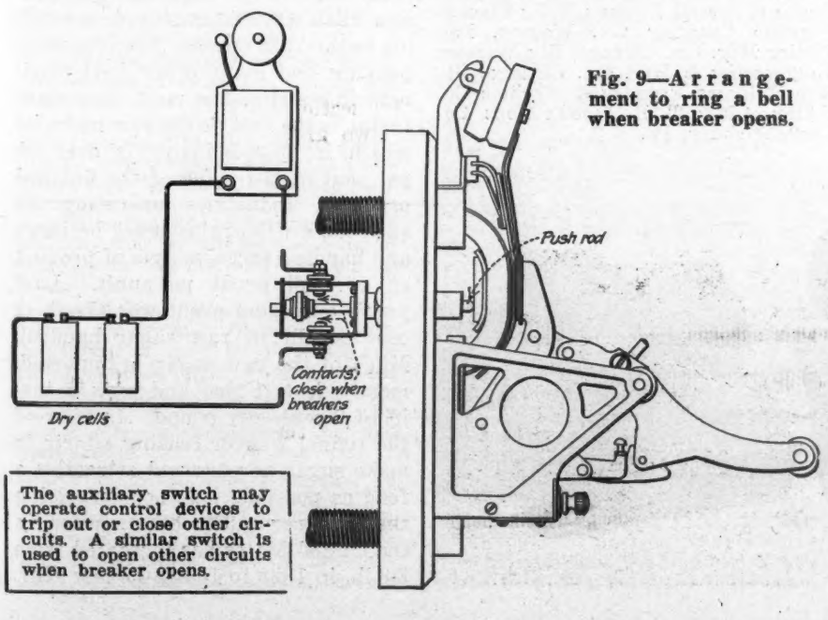


Fig. 9—Arrangement to ring a bell when breaker opens.

The auxiliary switch may operate control devices to trip out or close other circuits. A similar switch is used to open other circuits when breaker opens.

Installation and Care of Motors

(Continued from page 544)

as the commutator. If sandstone is not easily obtained, sand paper may be used by pressing it against the surface of the commutator with a block of wood shaped like the sandstone mentioned above. In both cases, the commutator should be run at a high rate of speed during polishing and the sandstone or sand paper moved back and forth along the surface parallel to the shaft. After this has been done, the commutator and brush faces should be carefully cleaned to remove any grit which might cut or scratch the com-

mutator. Emery cloth should never be used on a commutator or brush.

Slip Rings.—It is advisable to apply a little clean lubricating oil to the collector rings regularly. The oil may be applied with a piece of cloth or chamois skin.

Heating.—When a machine appears to be too hot to the touch, the actual temperature should be measured with a thermometer. The safe operating temperature of a motor or generator cannot be accurately determined by the hand, as it is impossible to hold the hand comfortably on a motor which has been heated to within its guarantee. The temperature rise for which a machine is guaranteed at its rated load is shown on its nameplate. The guarantee is based on the surrounding air temperature, assumed at 40 deg. C. (104 deg. F.) or less and the machine can be operated safely if its temperature by thermometer does not exceed 90 deg. C. or 194 deg. F.

Types and Kinds of Flexible Couplings

(Continued from page 533)

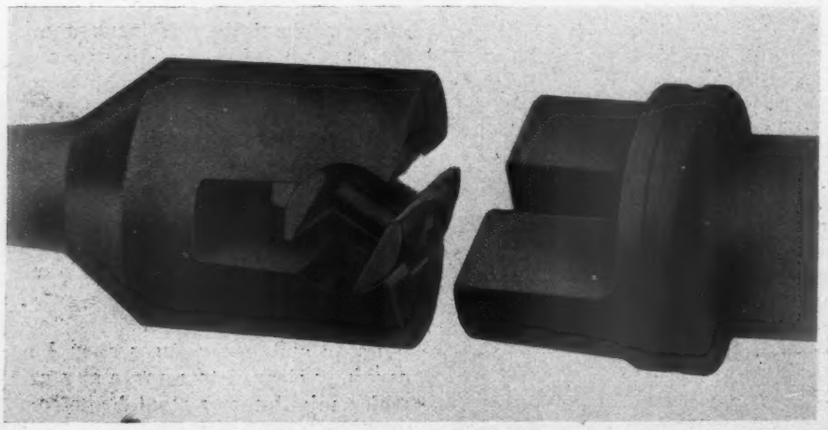
power at a varying angle rather than to take care of any off-center misalignment or endwise movement. To take care of any out-of-center misalignment with the universal-joint type of coupling, it is usually necessary to employ two such joints connected by an intermediate shaft. When it is necessary to provide for end-wise motion in addition, some external means must be employed, such as a splined shaft or some other modification.

Flexible couplings of the universal-joint type employing leather or steel disks are quite usual in the smaller sizes for some work and have been used even for larger work where two such joints are in combination to take care of out-of-center misalignment. Such combinations form an effective flexible coupling provided extreme accuracy is used in the making.

The points to be considered when specifying flexible couplings as well as a method of checking their alignment, when installed as well as rechecks at frequent periods after they have been in operation, will be discussed later in a continuation of this article.

EDITOR'S NOTE: Special acknowledgment is made to John J. Serrell, Smith & Serrell, Newark, N. J., and to the following companies for their kind assistance in furnishing information, counsel and illustrations for this and the other articles which appear in this series: Allis-Chalmers Mfg. Co., Milwaukee, Wis.; The Bartlett Hayward Co., Baltimore, Md.; Charles Bond Co., Philadelphia, Pa.; Bond Foundry & Machine Co., Manheim, Pa.; Brown Engineering Co., Reading, Pa.; The Carlyle Johnson Machine Co., Manchester, Conn.; Chicago Pulley & Shafting Co., Chicago, Ill.; Conway & Co., Cincinnati, Ohio; The Cutler-Hammer Mfg. Co., Milwaukee, Wis.; I. H. Dexter Co., Goshen, N. Y.; Dodge Manufacturing Co., Mishawaka, Ind.; Falls Clutch & Machinery Co., Cuyahoga Falls, Ohio; General Electric Co., Schenectady, N. Y.; The Hanson Clutch & Machinery Co., Tiffin, Ohio; The Hill Clutch Co., Cleveland, Ohio; The Hilliard Clutch & Machinery Co., Elmira, N. Y.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; The Medart Co., St. Louis, Mo.; Mesta Machine Co., West Homestead, Pa.; R. D. Nuttall Co., Pittsburgh, Pa.; The Pusey & Jones Co., Wilmington, Del.; Reeves Pulley Co., Columbus, Ind.; R. H. & F. M. Roots Co., Connersville, Ind.; A. L. Schultz & Son, Chicago, Ill.; Smith & Serrell, Newark, N. J.; Thomas Flexible Coupling Co., Warren, Pa.; Weller Mfg. Co., Chicago, Ill.; Western Engineering & Mfg. Co., Chicago, Ill.; The Williams Foundry & Machine Co., Akron, Ohio; T. B. Wood's Sons Co., Chambersburg, Pa.

A disassembled view of the universal joint type of flexible coupling sometimes used in steel mill work.



American Sugar Refining Company

(Continued from page 522)

operation of the factories that make the raw sugar. In these two factories 1,450,000 tons of cane are pressed to produce 160,000 tons of raw sugar, which makes cargoes for 40 ships. This amount of raw sugar is only 10 per cent of the total required per year by the company.

This company owns and operates six barrel factories with an annual output of 4,000,000 barrels. The material for making these is taken from the company's forests, covering over 500 sq. miles, and 113 miles of railroad have been constructed to bring the logs to the mills. Each year 700 ships dock at the different refineries of the company and discharge their cargoes which total 1,650,000 tons of raw sugar. The yearly output of the company, in sugar and syrup, amounts to about 80,000 carloads.

Formerly, sailing vessels of small tonnage brought the raw sugar in hogsheads and it was then transferred by carts to the refineries away from the waterfront. Now, ships of 10,000 tons burden land at the docks of the company, and their cargoes, with a minimum of rehandling, are dumped into the melting pan. The material is then handled by gravity and mechanical means until the finished product leaves the factory.

Although sugar is one of our important foods the industry is comparatively small. The industry ranks forty-eighth in value added by manufacture and also forty-eighth in total number of wage earners with less than 20,000 employed, according to the 1919 census. Like the meat packing and many other food products industries, the most important factor is the cost of the raw material which in this industry is over 90 per cent of the value of the finished product. Industries operating on such narrow margins must be large and handle a large volume of product at a small profit per unit. Last year's operating profit was about ¼ cent per lb. of raw sugar handled. Much of the raw sugar is imported, mostly from Cuba, and pays a tariff of 2 cents per pound. In view of the refiner's never ceasing efforts to make sugar as pure and attractive a food as possible, it is not surprising that the per capita consumption in the United States has increased from 8.8 lb. in 1823 to 103.18 lb. last year.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

The Dillon Electric Company, Canton, Ohio—Bulletins 207, 251 and 307 cover heavy and medium duty self-contained, direct-connected grinders and buffers of pedestal and bench types, which are made for either alternating or direct current. The heavy-duty grinders and buffers are made in 3-, 5- and 7½-hp. sizes, while the medium-duty grinders and buffers are made in ½-, 1- and 2-hp. sizes.

The Automatic Reclosing Circuit Breaker Company, Columbus, Ohio—Bulletin 313 describes the Type MSB automatic reclosing sectionalizing circuit breakers for direct current distribution systems. This bulletin gives the operating characteristics and design features, application, construction and operation of this Type MSB breaker, which is designed especially for use in direct-current distribution systems beyond the stations. It may be used interchangeably, without any modifications in the wiring or connections, to tie together feeders from the same or different stations or independent bus circuits or stub-end feeders.

Gisholt Machine Company, Madison, Wis.—Bulletin describes the "Precision Balancing Machine" which is an instrument for the accurate measurement and location of unbalance in motor and generator rotors, flywheels, crankshafts, spindles and other rotating machine parts.

R. and J. Dick Company, Inc., Passaic, N. J.—A small booklet describes and illustrates as well as gives instructions for splicing a 6-in., 5-ply "Dickbelt" endless. The joints made by several other metallic fasteners are also illustrated.

The Revolvator Company, 336-352 Garfield Avenue, Jersey City. N. J.—A small folder describes the nine standard models of revolvator piling machines which are made in capacities of 400 lb. upward and are able to pile material 6 to 20 ft. high according to requirements. This piling machine may be made to revolve on a turntable base so that it may be loaded on one side and material piled on the other by simply revolving it one quarter- or one half-way around after loading.

The United States Electrical Tool Company, Cincinnati, Ohio—Literature announces a new U. S. automatic ¼-in. electric drill recently placed on the market. This drill is of the universal type, ball bearing and possesses other advantageous construction details.

Herman H. Sticht and Company, 15 Park Row, New York City—The "Standco Megohmer," Bulletin 115, is especially adapted for acceptance and maintenance tests of low-voltage alternating and direct current motors and generators, of wiring installations, switches, switchboards, panel boards, receptacles, fixtures, railway signal equipment, and fire alarm telegraph systems. The theory on which this device operates as well as details of its construction, and instructions for use are included.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—Bulletins 9843 and 9872 give the special and optional features of design, capacity limitations, information required with order, general description, construction and approximate dimensions as well as a list of standard and optional features of alternating current, full-magnetic elevator controllers, for two-speed, high-power squirrel cage and slip-ring induction motors.

Reliance Instrument Company, 1135 Van Buren Street, Chicago, Ill.—Catalog 35 describes the line of Reliance portable and switchboard ammeters, milli-ammeters, volt-meters, milli-voltmeters, volt-ammeters, milli-voltmeters, and other special instruments for testing or measuring alternating and direct current. Several pages are devoted to giving drilling dimensions of switchboard instruments and diagrams showing how to connect ammeters and voltmeters in circuits.

The Euclid Crane and Hoist Company, Euclid, Ohio—Catalog 19 describes the Euclid electric hoists, monorail trolleys, traveling cranes, and wall and jib cranes. One of the special features of this loose-leaf book is the clearance drawing which gives the dimensions and installation allowances necessary for each of the standard types of hoist manufactured. A number of pages is devoted to illustrations of industrial hoist applications.

Gifford-Wood Company, Hudson, N. Y.—Bulletin 74 illustrates and describes the Gifford-Wood electric capstan car puller which makes a one-man job of "car spotting" in industrial plants.

The Falk Corporation, Milwaukee, Wis.—Bulletin 31 describes the Falk herringbone gears. Among the subjects taken up are the advantages, the application, material, types, design, gear cutting and special gear data with special instructions for ordering gears. Bulletin 32 gives similar information on Falk herringbone gear units for speed reduction.

American Engineering Company, Philadelphia, Pa.—A small folder describes the "Lo-Hed" monorail electric hoist which is built in capacities of 1,000 to 12,000 lb. The special feature of this hoist is in the low head room required, as the construction is such that the hoist hook will come to within 14 in. of the I-beam on the 3-ton hoist. This gives a higher lift which enables higher piling or storing and so economizes on storage space. It can also be installed advantageously in shops with low ceilings.

Automatic and Electric Furnaces, Ltd., 173-175 Farringdon Road, London, England, E. C. 1—A circular describes the Wild-Barfield stainless steel hardening equipment, an electric furnace especially designed to take care of stainless (high chrome) steel cutlery.

The Brookins Manufacturing Company, Dayton, Ohio—A folder describes the Brookins "Eclipse" gasoline blow torch which is made in three sizes—to hold a half-pint, a pint or a quart. A special feature of this torch is that it requires no pumping, as it generates its own pressure.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Leaflet 20,005 describes the Type OD Safety-First Fuse Box, which is designed for use on circuits carrying up to 100 amp. at voltages up to 7,500 volts, for protecting outdoor distributing transformers.

Condit Electrical Manufacturing Company, South Boston, Mass.—Bulletin 417-2 entitled "Condit Protective Relays and Accessories for Electrically-Operated Switchgear," includes a general description of each type of relay, with dimensions, with the contact arrangements, adjustments, construction and other special features connected with it. Some of the relays included are inverse definite-time-limit overload relays for switchboards, instantaneous overload relays for switchboards, inverse-time-limit overload relays for industrial use (series type), overload relays of series and through types and reverse power relays of series and through types. Among the accessories for electrically-operated switchgears are control switches with indicating lamp, instantaneous control relays, hesitating control relays, lockout or trip-free relays and under-voltage relays.

Link-Belt Company, 910 South Michigan Avenue, Chicago, Ill.—Book 480 entitled "Electric Hoists and Overhead Cranes" is not only profusely illustrated with photographs of actual installations of some of the more recent Link-Belt electric hoist installations, but has many line and wash drawings. In addition the subject of proper installation and efficient operation is fully covered with a wide variety of practices and methods employed by users in widely divergent fields.

Pennsylvania Flexible Metallic Tubing Company, 201 North Broad Street, Philadelphia, Pa.—Bulletin 55C describes the "Penflex" all-metal, heavy duty hose and coupling for tank car unloading.

The Manheim Manufacturing and Belting Company, Manheim, Pa.—How "Veelos" Balata belting is made and many of the advantages claimed for it, together with transmission and other operating data, are given in a small folder.

Smooth-On Manufacturing Company, 570-574. Communipaw Avenue, Jersey City, N. J.—Illustrated catalog No. 9, "Smooth-On Instruction Book".

shows when, where and how to use Smooth-On iron cement, paint and corrugated iron gaskets in making the numerous repairs necessary around industrial plants, in addition to listing a wide variety of uses together with a large number of illustrations and descriptions of actual repairs which have been made in a variety of industrial concerns.

Advance Electric Company, St. Louis, Mo.—Type WS single-phase, constant-speed motors, which are made in sizes from ⅛ to 7½ hp., are covered in Bulletin No. 16. Space is given to instructions for installation and care of the motor.

The Automatic Reclosing Circuit Breaker Company, Columbus, Ohio—Bulletin 402 describes the Type TR universal thermal relay for controlling circuits not exceeding 6 amp. at 125 volts or 3 amp. at 250 volts. This relay was primarily designed for the protection of electric motors against overloading, overheating and roasting and the resultant destruction and failure of the insulation.

Mica Insulator Company, 68 Church Street, New York City—A catalog entitled "Electrical Insulating Materials" gives a revised price list and discount sheet of the wide variety of electrical insulation materials, such as mica in various forms, cloth, cement, tape, sleeving, silk and many other products.

Edison Lamp Works of General Electric Company, Harrison, N. J.—Bulletin LD 110A, entitled "The Lighting of Textile Mills," devotes over thirty pages to a discussion of this subject on information compiled by A. L. Powell of the Lighting Service Department. Among the subjects discussed are: Reflecting equipment, spacing of outlets and size of lamps, general lighting scheme, detail recommendations for various types of mills, and so on.

Quadrangle Manufacturing Company, 553 West Monroe Street, Chicago, Ill.—A catalog entitled "Quad Lighting Units" describes a variety of fixtures for commercial and industrial purposes. In addition several pages are devoted to the discussion of illumination and methods of calculating the intensities with examples showing the application of these methods. The various types of socket and shadeholder steel-porcelain reflectors for industrial plants are illustrated.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—An 8-page booklet, Special Publication 1667, contains a list of over 300 installations of Westinghouse industrial heating apparatus and gives a more definite idea of the extent to which electricity is being used for industrial heating purposes. A few of the industries making use of electric heat are: manufacturers of abrasives, airplane factories, bakeries, furniture factories, foundries, hospitals, railway companies, restaurants and cafeterias, rubber mills, steel mills, textile machinery manufacturers, textile mills, tool manufacturers, and wire mills.

The Packard Electric Company, Warren Ohio—A 16-page booklet entitled "Installation and Care of Transformers" discusses the general rules covering transformer installations under the following headings: Inspection, drying, connection, handling, oil, hangers, general engineering recommendations, polarity connections and diagrams. Particular emphasis is placed on instructions for transformer installation and their care in use.

General Electric Company, Schenectady, N. Y.—A 12-page "Index to Descriptive Bulletins and Sheets" lists the various bulletins and other literature issued by the Publication Bureau. Another 16-page booklet entitled "Index to Instruction Book and Cards" lists the various instruction books and cards provided for the different kinds of equipment.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—Bulletin 6106 gives the features of design, dimensions, description, price and other features about direct-current automatic starters of the time-limit type with magnetic main contactors.

D. O. James Manufacturing Company, Chicago, Ill.—Bulletin 8 devotes over 100 pages to a discussion of the James spur and worm gear speed reducing transmissions and universal drives. A large number of illustrations shows this construction and the wide range of adaptability in service in many different lines of industry.

Sangamo Electric Company, Springfield, Ill.—Bulletin 61 gives instruction for the installation, use and operation of the Sangamo Type 8 single- and poly-phase watt-hour meters. A number of pages is devoted to diagrams and connections.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—A special 4-page bulletin describes the Westinghouse-Frankel Solderless Connections, which are made up in various types for different special uses.

B. F. Sturtevant Company, Hyde Park, Boston, Mass.—An attractive 56-page bulletin, No. 311, covers the Type 12 steam turbine. Part I gives in detail the construction and many of the applications; Part II is devoted to the care and operation, with special emphasis on lubrication, bearings, adjustment; Part III shows dis-assembled views and cross sections with every part properly listed and numbered.

Schweitzer and Conrad, Inc., 4435 Ravenswood Avenue, Chicago, Ill.—A 12-page bulletin, No. 223, entitled "Indoor Bus Supports, Style C," gives, in addition to a discussion of the various types, the prices and dimensions.

The Automatic Reclosing Circuit Breaker Company, Columbus, Ohio—Instruction Sheet 6 gives the wiring, mounting, potential adjustment, application and theory of operation, as well as diagram and part list for the Type F-2 relay which is used to control the operation of an automatic reclosing circuit breaker.

The Cowan Truck Company, Holyoke, Mass.—A group of five bulletins illustrate and describe various industrial applications of the Cowan hand lift trucks and skid system. For example, Bulletin 15 gives a general description of the hand truck in operation and its many economies. Bulletin 16 covers its use in facilitating manufacturing processes in machine shops and similar places. Bulletin 17 is on handling boxed, packaged, bottled and canned goods. Bulletin 18 is on handling bundled, rolled, sheet and bagged goods. Bulletin 20 describes the handling of lumber, furniture and similar loads.

Reliance Electric and Engineering Company, Ivanhoe Road, Cleveland, Ohio.—A 51-page reprint has been made of a paper entitled, "Anti-Friction Bearings in the Steel Mill," by A. M. MacCutcheon, chief engineer of this company, which was presented before the Association of Iron and Steel Electrical Engineers. This is of general interest and value to users and designers of machinery and power equipment in other industries.

The Arrow Electric Company, Hartford, Conn.—Catalog 20, on "Wiring Devices," devotes 160 pages to listing and illustrating the line of wiring devices. The condensed arrangement and grouping together of related devices and cross indexing has been planned for quick and easy reference.

Despatch Manufacturing Company, Minneapolis, Minn.—Catalog 4 devotes fifty-six pages to describing and illustrating electric ovens for annealing, armature and coil baking, temper drawing, drying, and a wide variety of other purposes.

Midwest Air Filters, Inc., 100 East Forty-Fifth Street, New York City—"Dust Problems and Their Solution," describes the applications of Northwest Air Filters in the solution of industrial dust problems such as high pressure and low pressure filters, compressor filters, paper and textile mills, in connection with heating and ventilating units, and in other applications.

Mitchell-Rand Manufacturing Company, 18 Vesey Street, New York City—Book 423, entitled, "Everything in Insulation," devotes 160 pages to a description of the different insulating materials, their uses and applications, as well as their insulating value. A number of valuable tables are included in the last ten pages. This is a handy book for reference.

Crescent Truck Company, Lebanon, Pa.—A group of loose-leaf folders in a binder describes the various types of Crescent electric industrial trucks and their applications. Among these are high wheeled, load carrying trucks for all around industrial service which are made in standard and short body for use on elevators. Tractors, low platform, and lift platform trucks are also described.

The Nichols-Lintern Company, 7960 Lorain Avenue, Cleveland, Ohio.—A folder, "It Takes Sand to Win," describes an electric sander which distributes sand on the runways of a traveling crane through the operation of hand or foot switch located in the operating cage.

Sumet Corporation, Ellicott Square, Buffalo, N. Y.—Three grades of Sumet babbitt for different industrial uses are described in a small folder.

The American Pulley Company, 4200 Wissahickon Avenue, Philadelphia, Pa.—A folder describes the American pressed steel hangers for line-shaft work.